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SIXTY YEARS A QUEEN.

THE SIXTIETH ANNIVERSARY OF THE ACCESSION OF QUEEN VICTORIA.

WITH the passing of the month of September, 1896, the present occupant of the throne of England is entitled to the distinction of having reigned longer than any previous sovereign, if not longer than any previous ruler in the history of all Europe; for, although Louis XIV became King of France in 1643, and reigned until the following century was fifteen years old, he was but a mere child at his accession, and had a minority of many years. There have been previous reigns of unusual length in English history, as, for instance, that of Henry III, who was crowned on October 28, 1216, and died in 1272; of Edward III, who reigned from 1327 to 1377; of that other famous Queen, Elizabeth, who wore the crown for forty-five years, and Henry VI, who reigned forty years; and last there was the eventful reign of the grandfather of Queen Victoria, George III, who held the throne from October 25, 1760, to January 29, 1820; although for the last eight years, from 1812 to 1820, his personal disability necessitated the appointment of a regent.

On June 20 of next year, the day set apart for celebration of the event in the British empire, Queen Victoria will have reigned sixty years, or one year longer than George III. The English people had originally intended to celebrate the event of her having reigned longer than any other British sovereign, some time during the past summer; but at the express wish of the Queen, it was decided to celebrate, not the mere fact that she had reigned one day longer than her grandfather, but the fact that she had completed (if she should be spared) a reign of sixty years. Next year, then, somewhere about June 20 or 21, we may look for such another spontaneous outburst of loyal feeling as was shown ten years ago in the celebration of the Queen's jubilee.

To those Americans who have not known the Englishman in his own country and in his own home the remarkable influence which the mere mention of "the Queen" exerts upon a people whose habits, tastes and government are so essentially popular and republican, whatever they may be in name, must be difficult to understand. It finds its counterpart in "the flag" of America. To the Englishman "the Queen" is representative and suggestive of all that is most sacred in the ties which bind him to his native land; there is, perhaps, no phrase which moves him more deeply, and the enthusiasm of a public dinner or a banquet, whether at home or in the far off colonies, is sure to reach its highest climax at the mention of the toast, "The Queen." To a close student of the political history of the English people during the reign of the present sovereign, it is abundantly evident that, although the government of England is monarchical in name, it is popular in fact—a government "of the people by the people." The people and the Parliament are one, and the moment that it has become evident that the governing party has lost touch with the people, it has hastened, frequently at a few days' notice, to subject itself to the test of the ballot. The vox populi heard at the polls has always found an attentive and invariably obedient listener on the throne, and never in the long course of her reign has Queen Victoria failed to carry out to the letter the instructions which have come from her subjects at a general election.

It is just here, in large measure, that she has won the profound respect and admiration of her subjects. For it has more than once occurred that the favorites of her Majesty have not been the choice of her people; yet in no single instance has she failed to subordinate her personal predilections to the expressed wish of the nation. Nor should it be said in disparagement of this womanly tact that probably the very existence of her throne depends upon her restraining the sovereign power of veto and at all times indorsing the action of her Parliament. It would be quite possible for an English sovereign to exert an enormous personal influence one way or the other in politics without directly exercising the powerful functions which belong to the throne. This the Queen has never done, or has done only on very rare, and, as the event has proved, very justifiable circumstances. For nigh upon sixty years she has ratified the measures which have come up from her people's Parliament for signature, and so on this ground alone has won for herself an amount of love and esteem which has grown with the passing years.

To her tact and good judgment in the exercise of her official duties, Queen Victoria has added the record of a blameless life. She is the embodiment of those private and domestic virtues which characterize the great middle class of the English people—a class which is justly regarded as the backbone of the nation. She has shown that not only may a woman be a queen, but a queen may be a woman. Exposed as her life has been to the strong light which beats upon a throne, there has never been a cloud to darken its moral purity. In this respect it stands out in clear relief upon the long roll of kings and queens that have sat upon the English throne.

In person, the queen is short and stout, and it is difficult to identify her with the graceful girl of twenty, as shown in the paintings in the early days of her reign; but she is said to preserve to this day the sweet grace and royal dignity for which she has always been famous. Her charm of manner and the womanly worth of her character were never so happily phrased as when a recent visiting American in proposing or responding to a toast in her honor spoke of "her queenliness as a woman and her womanliness as a queen."

It is impossible, within the limits of this article, to speak at any length of the remarkable history which is crowded into this long and eventful reign. In its material aspects it is the history of the civilized world. The opening years saw the dawn of that wonderful era of invention and discovery which included the development of the railway, the steamship and the telegraph. In 1837 people still traveled by stage coach, and the world was watching with curious eyes the early struggles of the locomotive. The practical telegraph had yet to be invented, and communication was carried on by the slow and uncertain mail coach. A thousand and one mechanical conveniences which are now regarded as the daily necessities of our life did not exist, or had not even been thought of. Education was the privilege of the few, and literature was costly. In political and social advancement the English people have made remarkable strides during the present reign. The franchise has been largely extended, and the condition of the working classes vastly improved, and while, of course, no one would assign all this advancement in material and national prosperity to the direct influence of the Queen—as would undoubtedly have been done in some courtly address to good Queen Bess of three hundred years ago—it is certain that the indirect influence of the character of Queen Victoria has contributed largely to the welfare of her subjects.

We are indebted for our illustration to the courtesy of the Illustrated London News.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.*

ADDRESS BY THE PRESIDENT TO THE MATHEMATICAL AND PHYSICAL SECTION.

THERE is a melancholy reminiscence connected with this meeting of our section, for when the British Association last met in Liverpool the chair in Section A was occupied by Clerk-Maxwell. In the quarter of a century which has elapsed since that meeting one of the most important advances made in our science has been the researches which, inspired by Maxwell's view of electrical action, confirmed that view, and revolutionized our conception of the processes occurring in the electro-magnetic field. When the association last met in Liverpool, Maxwell's view was almost without supporters, to-day its opponents are fewer than its supporters then. Maxwell's theory, which is the development and extension of Faraday's, has not only affected our way of regarding the older phenomena of electricity, it has, in the hands of Hertz and others, led to the discovery of whole regions of phenomena previously undreamed of. It is sad to think that his premature death prevented him from reaping the harvest he had sown. His writings are, however, with us, and are a storehouse to which we continually turn, and never, I think, without finding something valuable and suggestive.

"Thus ye teach us, day by day,
Wisdom, though now far way."

The past year has been rich in matters of interest to physicists. In it has occurred the jubilee of Lord Kelvin's tenure of the professorship of natural philosophy at the University of Glasgow. Some of us were privileged to see this year at Glasgow an event unprecedented in the history of physical science in England, when congratulations to Lord Kelvin on the jubilee of his professorship were offered by people of every condition and country. Every scientific society and every scientific man is Lord Kelvin's debtor; but no society and no body of men owe him a greater debt than Section A of the British Association; he has done more for this section than any one else; he has rarely missed its meetings, he has contributed to the section papers which will make its proceedings imperishable, and by his enthusiasm he has year by year inspired the workers of this section to renew with increased vigor their struggle to penetrate the secrets of nature. Long may we continue to receive from him the encouragement and assistance which have been so freely given for the past half century.

By the death of Sir W. R. Grove, the inventor of Grove's cell, we have lost a physicist whose name is a familiar one in every laboratory in the world. Besides the Grove cell, we owe to him the discovery of the gas battery, and a series of researches on the electrical behavior of gases, whose importance is only now beginning to be appreciated. His essay on the correlation of the physical forces had great influence in promoting that belief in the unity of the various branches of physics which is one of the characteristic features of modern and natural philosophy.

In the late Prof. Stoletow, of Moscow, we have lost the author of a series of most interesting researches on the electrical properties of gases illuminated by ultraviolet light, researches which, from their place of publication, are, I am afraid, not so well known in this country as they deserve to be.

As one who, unfortunately, of late years has had only too many opportunities of judging of the teaching of science in our public and secondary schools, I should like to bear testimony to the great improvement which has taken place in the teaching of physics in these schools during the past ten years. The standard attained in physics by the pupils of these schools is increasing year by year, and great credit is due to those by whose labors this improvement has been accomplished. I hope I may not be considered ungrateful if I express the opinion that in the zeal and energy which is now spent in the teaching of physics in schools there may lurk a temptation to make the pupils cover too much ground. You may by careful organization and arrangement insure that boys shall be taken over many branches of physics in the course of a short time; it is, indeed, not uncommon to find boys of seventeen or eighteen who have compassed almost the whole range of physical subjects. But, although you may increase the rate at which information is acquired, you cannot increase in anything like the same proportion the rate at which the subject is assimilated, so as to become a means of strengthening the mind and a permanent mental endowment when the facts have long been forgotten.

Physics can be taught so as to be a subject of the greatest possible educational value, but when it is so, it is not so much because a student acquires a knowledge of a number of interesting and important facts, as by the mental training the study affords in, as Maxwell said, "bringing our theoretical knowledge to bear on the objects and the objects on our theoretical knowledge." I think this training can be got better by going very slowly through such a subject as mechanics, making the students try innumerable experiments of the simplest and, what is a matter of importance in school teaching, of the most inexpensive kind, but always endeavoring to arrive at numerical results rather than by attempting to cover the whole range of mechanics, light, heat, sound, electricity and magnetism. I confess I regret the presence in examinations intended for school boys of many of these subjects.

I think, too, that in the teaching of physics at our universities there is, perhaps, a tendency to make the course too complex and too complete. I refer especially to the training of those students who intend to become physicists. I think that after a student has been trained to take accurate observations, to be alive to those pitfalls and errors to which all experiments are liable, mischief may, in some cases, be done if he is kept performing elaborate experiments, the results of which are well known, with the view of learning a knowledge of methods. It is not given to many to wear a load of learning lightly as a flower. With many students a load of learning, especially if it takes a long time to acquire it, is apt to crush enthusiasm. Now there is, I think, hardly any quality more essential to success in physical investigations than enthusiasm. Any investigation in experimental physics requires a large expenditure of both time and patience; the apparatus seldom, if ever, begins by behaving as it ought; there are times when all the forces of nature, all the properties of matter, seem to be fighting against you; the instruments behave in the most capricious way, and we appreciate Coutts Trotter's saying that the doctrine of the constancy of nature was never discovered in a laboratory.

These difficulties have to be overcome, but it may take weeks or months to do so, and unless the student is enthusiastic, he is apt to retire disheartened from the contest. I think, therefore, that the preservation of youthful enthusiasm is one of the most important points for consideration in the training of physicists. In my opinion this can best be done by allowing the student, even before he is supposed to be acquainted with the whole of physics, to begin some original research of a simple kind under the guidance of a teacher who will encourage him and assist in the removal of difficulties. If the student once tastes the delights of the successful completion of an investigation, he is not likely to go back, and will be better equipped for investigating the secrets of nature than if, like the White Knight in "Alice in Wonderland," he commenced his career provided with the means of measuring or weighing every physical quantity under the sun, but with little desire or enthusiasm to have anything to do with any of them. Even for those students who intend to devote themselves to other pursuits than physical investigation, the benefits derived from original investigation as a means of general education can hardly be overestimated; the necessity it entails of independent thought, perseverance in overcoming difficulties and the weighing of evidence gives it an educational value which can hardly be rivaled. We have to congratulate ourselves that through the munificence of Mr. Ludwig Mond, in building and endowing a laboratory for research, the opportunities for pursuing original investigations in this country have been greatly increased.

The discovery at the end of last year by Prof. Roentgen of a new kind of radiation from a highly exhausted tube through which an electric discharge is passing, has aroused an amount of interest unprecedented in the history of physical science. The effects produced inside such a tube by the cathode rays, the bright phosphorescence of the glass, the shadows thrown by opaque objects, the deflection of the rays by a magnet, have, thanks to the researches of Crookes and Goldstein, long been familiar to us, but it is only recently that the remarkable effects which occur outside such a tube have been discovered. In 1893, Lenard, using a tube provided with a window made of a very thin plate of aluminum, found that a screen impregnated with a solution of a phosphorescent substance became luminous if placed outside the tube in the prolongation of the line from the cathode through the aluminum window. He also found that photographic plates placed outside the tube in this line were affected, and electrified bodies were discharged; he also obtained by these rays photographs through plates of aluminum or quartz. He found that the rays were affected by a magnet, and regarded them as the prolongations of the cathode rays. This discovery was at the end of last year followed by that of Roentgen, who found that the region round the discharge tube is traversed by rays which can affect a photographic plate after passing through substances such as aluminum or cardboard, which are opaque to ordinary light; which pass from one substance to another, without any refraction, and with but little regular reflection, and which are not affected by a magnet. We may, I think, for the purposes of discussion, conveniently divide the rays occurring in or near a vacuum tube traversed by an electric current into three classes without thereby implying that they are necessarily distinctly different in physical character. We have (1) the cathode rays inside the tube, which are deflected by a magnet; (2) the Lenard rays outside the tube, which are also deflected by a magnet; and (3) the Roentgen rays, which are not, as far as is known, deflected by a magnet. Two views are held as to the nature of the cathode rays; one view is, that they are particles of gas carrying charges of negative electricity and moving with great velocities which they have acquired as they traveled through the intense electric field which exists in the neighborhood of the negative electrode. The phosphorescence of the glass is on this view produced by the impact of these rapidly moving charged particles, though whether it is produced by the mechanical violence of the impact or whether it is due to an electro-magnetic impulse produced by the sudden reversal of the velocity of the negatively charged particle—whether, in fact, it is due to mechanical or electrical causes, is an open question. This view of the constitution of the cathode rays explains in a simple way the deflection of those rays in a magnetic field, and it has lately received strong confirmation from the results of an experiment made by Perrin. Perrin placed inside the exhausted tube a cylindrical metal vessel with a small hole in it, and connected this cylinder with the leaves of a gold leaf electroscope. The cathode rays could, by means of a magnet, be guided so as either to pass into the cylinder through the aperture or turned quite away from it. Perrin found that when the cathode rays passed into the cylinder the gold leaf of the electroscope diverged and had a negative charge, showing that the bundle of cathode rays inclosed by the cylinder had a charge of negative electricity. Crookes had many years ago exposed a disk connected with a gold leaf electroscope to the bombardment of the cathode rays, and found that the disk received a slight positive charge; with this arrangement, however, the charged particles had to give up their charges to the disk if the gold leaves of the electroscope were to be affected, and we know that it is extremely difficult, if not impossible, to get electricity out of a charged gas merely by bringing the gas in contact with a metal. Lord Kel-

* Liverpool meeting, beginning September 16, 1896, and published in Science.

vin's electric strainers are an example of this. It is a feature of Perrin's experiment that since it acts by induction, the indications of the electroscope are independent of the communication of the charges of electricity from the gas to the cylinder, and since the cathode rays fall on the inside of the cylinder, the electroscope would not be affected, even if there were such an effect as is produced when ultra-violet light falls upon the surface of an electro-negative metal when the metal acquires a positive charge. Since any such process cannot affect the total amount of electricity inside the cylinder, it will not affect the gold leaves of the electroscope; in fact, Perrin's experiments prove that the cathode rays carry a charge of negative electricity.

The other view held as to the constitution of the cathode rays is that they are waves in the ether. It would seem difficult to account for the result of Perrin's experiment on this view, and also I think very difficult to account for the magnetic deflection of the rays. Let us take the case of a uniform magnetic field. The experiments which have been made on the magnetic deflection of these rays seem to make it clear that in a magnetic field which is sensibly uniform the path of these rays is curved; now if these rays were due to ether waves, the curvature of the path would show that the velocity of propagation of these waves varied from point to point of the path. That is, the velocity of propagation of these waves is not only affected by the magnetic field, it is affected differently at different parts of the field. But in a uniform field what is there to differentiate one part from another so as to account for the variability of the velocity of wave propagation in such a field? This could not be accounted for by supposing that the velocity of this wave motion depended on the strength of the magnetic field, or that the magnetic field, by distorting the shape of the boundary of the negative dark space, changed the direction of the wave front, and so produced a deflection of the rays. The chief reason for supposing that the cathode rays are a species of wave motion is afforded by Lenard's discovery, that when the cathode rays in a vacuum tube fall on a thin aluminum window in the tube, rays having similar properties are observed on the side of the window outside the tube; this is readily explained on the hypothesis that the rays are a species of wave motion to which the window is partially transparent, while it is not very likely that particles of the gas in the tube could force their way through a piece of metal. This discovery of Lenard's does not, however, seem to me incompatible with the view that the cathode rays are due to negatively charged particles moving with high velocities. The space outside Lenard's tube must have been traversed by Roentgen rays; these would put the surrounding gas in a state in which a current would be readily started in the gas if any electromotive force acted upon it. Now, though the metal window in Lenard's experiments was connected with the earth, and would, therefore, screen off from the outside of the tube any effect arising from slow electrostatic changes in the tube, it does not follow that it would be able to screen off the electrostatic effect of charged particles moving to and from the tube with very great rapidity. For, in order to screen off electrostatic effects, there must be a definite distribution of electrification over the screen; changes in this distribution, however, take a finite time, which depends upon the dimensions of the screen and the electrical conductivity of the material of which it is made. If the electrical changes in the tube take place at above a certain rate, the distribution of electricity on the screen will not have time to adjust itself and the screen will cease to shield off all electrostatic effects. Thus the very rapid electrical changes which would take place if rapidly moving charged bodies were striking against the window, would give rise to electromotive forces in the region outside the window, and would produce convection currents in the gas which has been made a conductor by the Roentgen rays. The Lenard rays would thus be analogous in character to the cathode rays, both being convective currents of electricity. Though there are some points in the behavior of these Lenard rays which do not admit of a very ready explanation from this point of view, yet the difficulties in its way seem to me considerably less than that of supposing that a wave in the ether can change its velocity when moving from point to point in a uniform magnetic field.

I now pass on to the consideration of the Roentgen rays. We are not yet acquainted with any crucial experiment which shows unmistakably that these rays are waves of transverse vibration in the ether, or that they are waves of normal vibration, or indeed that they are vibrations at all. As a working hypothesis, however, it may be worth while considering the question whether there is any property known to be possessed by these rays which is not possessed by some form or other of light. The many forms of light have in the last few months received a noteworthy addition by the discovery of M. Becquerel of an invisible radiation, possessing many of the properties of the Roentgen rays, which is emitted by many fluorescent substances, and to an especially marked extent by the uranium salts. By means of this radiation, which, since it can be polarized, is unquestionably light, photographs through opaque substances similar to though not so beautiful as those obtained by means of Roentgen rays can be taken, and, like the Roentgen rays, they cause an electrified body on which they shine to lose its charge, whether this be positive or negative.

The two respects in which the Roentgen rays differ from light is in the absence of refraction and perhaps of polarization. Let us consider the absence of refraction first. We know cases in which special rays of the spectrum pass from one substance to another without refraction; for example, Kundt showed that gold, silver, and copper allowed some rays to pass through them without bending, while other rays are bent in the wrong direction. Pflüger has lately found that the same is true for some of the aniline dyes when in a solid form. In addition to this, the theory of dispersion of light shows that there will be no bending when the frequency of the vibration is very great. I have here a curve taken from a paper by Helmholtz, which shows the relation between the refractive index and the frequency of vibration for a substance whose molecules have a natural period of vibration, and one only; the frequency of this vibration is represented by OK in the diagram. The refractive index increases with the frequency of the light until the latter is equal to the frequency of the natural vibration of the substance; the refractive index then diminishes, becomes less than unity, and finally approaches unity, and practically is equal to it when the frequency of the light greatly exceeds that of the natural vibration of the molecule. Helmholtz's results are obtained on the supposition that a molecule of the refracting substance consists of a pair of oppositely electrified atoms, and that the specific inductive capacity of the medium consists of two parts, one due to the ether, the other to the setting of the molecules along the lines of electric force.

Starting from this supposition, we can easily see without mathematical analysis that the relation between the refractive index and the frequency must be of the kind indicated by the curve. Let us suppose that an electromotive force of given amplitude acts on this mixture of molecules and ether, and start with the frequency of the external electromotive force less than that of the free vibrations of the molecules; as the period of the force approaches that of the molecules, the effect of the force in pulling the molecules into line will increase; thus the specific inductive capacity, and therefore the refractive index, increases with the frequency of the external force; the effect of the force on the orientation of the molecules will be greatest when the period of the force coincides with that of the molecules. As long as the frequency of the force is less than that of the molecules, the external field tends to make the molecules set so as to increase the specific inductive capacity of the mixture; as soon, however, as the frequency of the force exceeds that of the molecules, the molecules, if there are no viscous forces, will all topple over and point so as to make the part of the specific inductive capacity due to the molecules of opposite sign to that due to the ether. Thus, for frequencies greater than that of the molecules the specific inductive capacity will be less than unity. When the frequency of the force only slightly exceeds that of the molecules, the effect of the external field on the molecules is very great, so that if there are a considerable number of molecules, the negative part of the specific inductive capacity due to the molecules may be greater than the positive part due to the ether, so that the specific inductive capacity of the mixture of molecules and ether would be negative; no waves of this period could then travel through the medium, they would be totally reflected from the surface.

As the frequency of the force gets greater and greater, its effect in making the molecules set will get less and less, but the waves will continue to be totally reflected until the negative part of the specific inductive capacity due to the molecules is just equal to the positive part due to the ether. Here the refractive index of the mixture is zero. As the frequency of the force increases, its effect on the molecules gets less and less, so that the specific inductive capacity continually approaches that due to the ether alone, and practically coincides with it as soon as the frequency of the force is a considerable multiple of that of the molecules. In this case both the specific inductive capacity and the refractive index of the medium are the same as that of the ether and there is consequently no refraction. Thus the absence of refraction, instead of being in contradiction to the Roentgen rays, being a kind of light, is exactly what we should expect if the wave length of the light were exceedingly small.

The other objection to these rays being a kind of light is, that there is no very conclusive evidence of the existence of polarization. Numerous experiments have been made on the difference between the absorption of these rays by a pair of tourmaline plates when their axes are crossed or parallel. Many observers have failed to observe any difference at all between the absorption in the two cases. Prince Galitzine and M. De Karnogitsky, by a kind of cumulative method, have obtained photographs which seem to show that there is a slightly greater absorption when the axes are crossed than there is when the axes are parallel. There can, however, be no question that the effect, if it exists at all, is exceedingly small compared with the corresponding effect for visible light. Analogy, however, leads us to expect that to get polarization effects we must use, in the case of short waves, polarizers of a much finer structure than would be necessary for long ones. Thus a wire bird cage will polarize long electrical waves, but will have no effect on visible light. Rubens and Dubois made an instrument which would polarize the infra-red rays by winding very fine wires very close together on a framework; this arrangement, however, was too coarse to polarize visible light. Thus, though the structure of the tourmaline is fine enough to polarize the visible rays, it may be much too coarse to polarize the Roentgen rays, if these have exceedingly small wave lengths. As far as our knowledge of these rays extends, I think we may say that though there is no direct evidence that they are a kind of light, there are no properties of the rays which are not possessed by some variety of light.

It is clear that if the Roentgen rays are light rays, their wave lengths are of an entirely different order to those of visible light. It is, perhaps, worth notice that on the electro-magnetic theory of light we might expect two different types of vibration if we suppose that the atoms in the molecule of the vibrating substance carried electrical charges. One set of vibrations would be due to the oscillations of the bodies carrying the charges, the other set to the oscillation of the charges on these bodies. The wave length of the second set of vibrations would be commensurate with molecular dimensions; can these vibrations be the Roentgen rays? If so, we should expect them to be damped with such rapidity as to resemble electrical impulses rather than sustained vibrations.

If we turn from the rays themselves to the effects they produce, we find that the rays alter the properties of the sub tances through which they are passing. This change is most apparent in the effects produced on the electrical properties of the substances. A gas, for example, while transmitting these rays, is a conductor of electricity. It retains its conducting properties for some little time after the rays have ceased to pass through it, but Mr. Rutherford and I have lately found that the conductivity is destroyed if a current of electricity is sent through the Roentgenized gas. The gas in this state behaves in this respect like a very dilute solution of an electrolyte. Such a solution would cease to conduct after enough electricity had been sent through it to electrolyze all the molecules of the electrolyte. When a current is passing through a gas exposed to the rays, the current destroys and the rays produce the structure which gives conductivity to the gas; when things have reached a steady state, the rate of destruction by the current must equal the rate of production by the rays. The current can thus not exceed a definite value, otherwise more of the conducting gas would be destroyed than is produced.

This explains the very characteristic feature that in the passage of electricity through gases exposed to Roentgen rays the current, though at first proportional to the electromotive force, soon reaches a value where it is almost constant and independent of electromotive force, and we get to a state when a tenfold increase in the electromotive force only increases the current by a few per cent. The conductivity under the Roentgen rays varies greatly from one gas to another; the halogens and their gaseous compounds, the compounds of sulphur and mercury vapor, are among the best conductors. It is worthy of note that those gases which are the best conductors when exposed to the rays are either elements or compounds of elements which have in comparison with their valency very high refractive indices.

The conductivity conferred by the rays on a gas is not destroyed by a considerable rise in temperature; it is, for example, not destroyed if it be sucked through metal tubing raised to a red heat. The conductivity is, however, destroyed if the gas is made to bubble through water, it is also destroyed if the gas is forced through a plug of glass wool. This last effect seems to indicate that the structure which confers conductivity on the gas is of a very coarse kind, and we get confirmation of this from the fact that a very thin layer of gas exposed to the Roentgen rays does not conduct nearly so well as a thicker one. I think we have evidence from other sources that electrical conduction is a process that requires a considerable space—a space large enough to inclose a very large number of molecules.

Thus Koller found that the specific resistances of petroleum, turpentine and distilled water, when determined from experiments made with very thin layers of these substances, were very much larger than those determined from experiments with thicker layers. Even in the case of metals there is evidence that the metal has to be of appreciable size if it is to conduct electricity. The theory of the scattering of light by small particles shows that, if we assume the truth of the electro-magnetic theory of light, the effects should be different according as the small particles are insulators or conductors. When the small particles are non-conductors, theory and experiment concur in showing that the direction of complete polarization for the scattered light is at right angles to the direction of the incident light, while if the small particles are conductors, theory indicates that the direction of complete polarization makes an angle of 60° with the incident light. This result is not, however, confirmed by the experiments made by Prof. Threlfall on the scattering of light by very small particles of gold. He found that the gold scattered the light in just the same way as a non-conductor, giving complete polarization at right angles to the incident light. This would seem to indicate that those very finely divided metallic particles no longer acted as conductors. Thus there seems evidence that in the case of conduction through gases, through badly conducting liquids and through metals, electric conduction is a process which requires a very considerable space and aggregations of large numbers of molecules. I have not been able to find any direct experimental evidence as to whether the same is true for electrolytes. Experiments on the resistance of thin layers of electrolytes would be of considerable interest, as according to one widely accepted view of electrolysis conduction through electrolytes, so far from being effected by aggregations of molecules, takes place by means of the ion, a structure simpler than that of the molecule, so that if this represents the process of conduction, there would not seem room for the occurrence of an effect which occurs with every other kind of conduction.

In this building it is only fitting that some reference should be made to the question of the movement of the ether. You are all, doubtless, acquainted with the heroic attempts made by Prof. Lodge to set the ether in motion, and how successfully the ether resisted them. It seems to be conclusively proved that a solid body in motion does not set in motion the ether at an appreciable distance outside it; so that if the ether is disturbed at all in such a case, the disturbance is not comparable with that produced by a solid moving through an incompressible fluid, but must be more analogous to that which would be produced by the motion through the liquid of a body of very open structure, such as a piece of wire netting, where the motion of the fluid only extends to a distance comparable with the diameter of the wire, and not with that of the piece of netting.

There is another class of phenomena relating to the movement of the ether which is, I think, deserving of consideration, and that is the effect of a varying electromagnetic field in setting the ether in motion. I do not remember to have seen it pointed out that the electromagnetic theory of light implicitly assumes that the ether is not set in motion even when acted on by mechanical forces. On the electro-magnetic theory of light such forces do exist, and the equations used are only applicable when the ether is at rest. Consider, for example, the case of a plane electric wave traveling through the ether. We have parallel to the wave front a varying electric polarization, which on the theory is equivalent to a current; at right angles to this, and also in the wave front, we have a magnetic force. Now, when a current flows through a medium in a magnetic field there is a force acting on the medium at right angles to the plane, which is parallel both to the current and to the magnetic force; there will thus be a mechanical force acting on each unit volume of the ether when transmitting an electric wave, and since this force is at right angles to the current and to the magnetic force, it will be in the direction in which the wave is propagated. In the electro-magnetic theory of light, however, we assume that this force does not set the ether in motion, as unless we made this assumption we should have to modify our equations; as the electro-magnetic equations are not the same in a moving field as in a field at rest. In fact, a complete discussion of the transmission of electro-magnetic disturbances requires

a knowledge of the constitution of the ether which we do not possess. We now assume that the ether is not set in motion by an electro-magnetic wave. If we do not make this assumption, we must introduce into our equation quantities representing the components of the velocity of the ether, and unless we know the constitution of the ether, so as to be able to deduce these velocities from the forces acting on it, there will be in the equations of the electro-magnetic field more unknown quantities than we have equations to determine. It is, therefore, a very essential point in electro-magnetic theory to investigate whether or not there is any motion of the ether in a varying electro-magnetic field. We have at the Cavendish Laboratory, using Prof. Lodge's arrangement of interference fringes, made some experiments to see if we could detect any movement of the ether in the neighborhood of an electric vibrator, using the spark which starts the vibrations as the source of light. The movement of the ether, if it exists, will be oscillatory, and with an undamped vibrator the average velocity would be zero; we used, therefore, a heavily damped vibrator, with which the average velocity might be expected to be finite. The experiments are not complete, but so far the results are entirely negative. We also tried by the same method to see if we could detect any movement of the ether in the neighborhood of a vacuum tube emitting Roentgen rays, but could not find any trace of such a movement. Prof. Threlfall, who independently tried the same experiment, has, I believe, arrived at the same conclusion.

Unless the ether is immovable under the mechanical forces in a varying electro-magnetic field, there are a multitude of phenomena awaiting discovery. If the ether does move, then the velocity of transmission of electrical vibrations, and therefore of light, will be affected by a steady magnetic field. Such a field, even if containing nothing but ether, will behave toward light like a crystal, and the velocity of propagation will depend upon the direction of the rays. A similar result would also hold in a steady electric field. We may hope that experiments on these and similar points may throw some light on the properties of that medium which is universal, which plays so large a part in our explanation of physical phenomena, and of which we know so little.

J. J. Thomson.

THE ACTION OF LIGHT UPON PERFUMES.

In a preceding article we described a process devised by Mr. E. Mesnard for comparing the intensity of perfumes. The same investigator has endeavored to produce an apparatus that should be less delicate and more easily transportable, and that should give just as accurate results. The model that he has decided upon is very ingenious. We shall give a brief description of it, as seen by us in operation at M. Gaston Bonnier's botanical laboratory.

In an oblong box provided with a hinged cover (Fig. 1) there are arranged two parallel cylinders of fine wire gauze, each mounted upon a horizontal axis. Each cylinder is maneuvered from the exterior by means of a winch placed at one of the extremities of the axis. The other extremity of this axis carries a graduated disk which moves along a fixed rule that is likewise graduated. It is possible in this way to estimate the number of revolutions and fractions thereof communicated to each of the cylinders.

Fig. 1.—APPARATUS FOR COMPARING ODORS.

It is in the oblong box that the odors are mixed. To this effect there is placed externally a frame divided into two compartments, each of which contains a small grooved pulley over which passes a thread. This thread, thoroughly saturated with the essential oil, is dried by its passage through a wad of cotton, enters the box through a very small orifice and afterward winds around one of the cylinders.

By this arrangement, it is therefore possible, at one's will, to cause a certain length of thread impregnated with essential oil to wind up in the box, or else to cause the thread that was first inclosed in the frame to reenter the latter in order to become saturated anew. It will be readily understood that upon winding a greater or less length of thread around the cylinder, there is introduced into the box a quantity of essential oil that is proportional to the length of the thread wound.

The cover is provided with an orifice surmounted by a cone that has exactly the form of the nose and permits of obtaining a smell of the interior when a valve is opened through a pressure upon a small button properly arranged. If it is a question of comparing two essential oils, one of the threads is impregnated with the unknown oil and the other with spirit of turpentine taken as a standard, and an endeavor is made to ascertain what length of this latter thread must be introduced into the box in order to produce upon the olfactory membrane an odoriferous intensity equivalent to that which is produced by a given length of thread impregnated with the unknown essential oil.

This therefore amounts, upon the whole, to the same thing as measuring the intensity of a perfume with a meter measure. The model just described is especially arranged for the comparison of the intensity of liquid perfumes. If it is desired to experiment upon a bouquet of flowers, the latter is introduced into a cylinder closed by rubber cloth and connected with the apparatus by properly arranged tubes.

This arrangement is no longer applicable when it is a question of but a single flower, whose odor is necessarily too feeble to allow of its being led to a distance by tubes. The apparatus is then modified (Fig. 2).

The box, which is carried by a small support and stands vertically, is open at the bottom, in order to allow the flowering top of the plant to enter it; but it may afterward be inclosed in rubber cloth tied around the stalk with a cord. The top of the box is arranged as before. It contains an orifice provided with a valve and a piece to which the nose is applied when it is desired to obtain a smell of the interior. In this way the nose is very near the flower.

At the side of the box there is a frame that carries the mechanism designed to measure the quantity of spirit of turpentine necessary to neutralize the intensity of the flower's perfume.

In both models of the apparatus the mixing of the odors is effected by means of rubber bulbs. The cleaning of the tubes is effected by means of a current of hot air. Thanks to these apparatus, Mr. Mesnard has been able to perform a large number of experiments, of which we shall give only the results.

It is light, and not oxygen, as is commonly thought, that is the principal cause of the destruction of odoriferous substances; but these two agents seem sometimes to combine their effects in such a way as to produce a maximum action.

The action of light manifests itself in two different ways. On the one hand, it acts as a chemical power capable of furnishing energy to all the transformations through which odoriferous substances pass from their elaboration to their total resinification. On another hand, it exerts a mechanical action that permits of explaining the method of periodical disengagement of the perfume of flowers.

The intensity of the perfume disengaged by a plant depends upon the state of equilibrium that is established at every hour of the day between the pressure of the water in the cells (which tends to expel to the exterior the essential oils contained in the epidermis) and the action of light, which combats such turgescence. Just as a simple watering suffices to increase the turgescence of the cells, so the interposition of a simple glass screen, the presence of a cloud or the advent of cloudy or rainy weather suffice to greatly attenuate the effect produced by light. In both cases the intensity of the perfume increases.

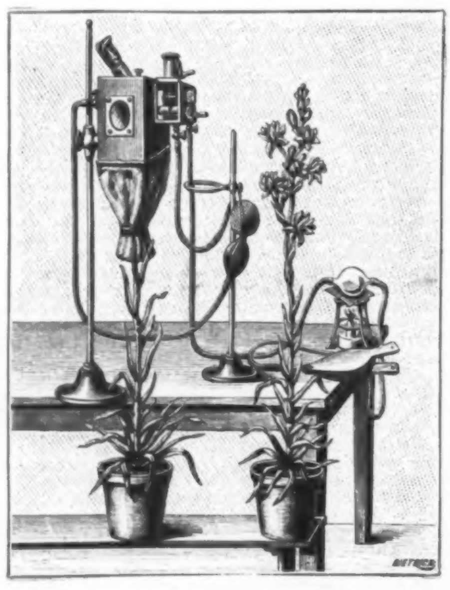


Fig. 2.—APPARATUS FOR MEASURING THE INTENSITY OF PERFUMES.

In reality, it is the irritability of the protoplasm that is the primordial cause of the variation in intensity of the perfume of flowers, and experiment proves that a sudden insolation or simple contact suffices to provoke such irritability, and consequently to bring about a notable variation in the state of equilibrium of the plant and an almost sudden increase of the intensity of the perfume.

The alternations of day and night determine maximum and minimum values of the intensity of perfumes, which are often modified, it is true, by the changeableness of the weather, but which nevertheless bring about a true periodicity in the disengagement of odors. There are some plants that are more sensitive than others, certain orchids, for example, in which such periodicity occurs in a much more marked manner.—La Nature.

THE CAUSES OF COLOR.

By J. J. Stewart, B.A. Cantab., B.Sc. Lond., in Knowledge.

The beauty of the objects of nature around us depends so much on the varieties of color which they exhibit that it becomes an interesting question, What is the cause of these differences? We have only to think of the blue sky, the green foliage, and the various splendors of flowers and fruits to realize to how great a degree the pleasure we experience in viewing a country scene is due to the many-hued surfaces of natural objects. The pleasurable feelings aroused by the sight of the deep blue of the sea contrasting with the bright red color of the sandstone cliffs, or the effect of the sunshine when it lights up the splendid purple of the heather on the slopes of the hills, can be forgotten by none who have experienced them; and the striking effect of Eastern scenes is owing largely to the brilliance of the tints which meet the eye. It is needless to enlarge on the part played by color in this world of ours; the difference between a world of color and one in which surrounding objects were only distinguished by different shades of gray can be realized by all.

When we come to inquire how the red color of a rose is produced, and why it differs in appearance from a blue flower, we must consider what happens to the light which falls upon the petals of the rose. We see the flower because the light from the sun is reflected from it, but something has happened to the light before it reaches our eyes: the light we receive differs from that which fell upon the flower. The rays from the sun penetrate to a certain extent into the substance of the flower, and most of them are reflected from particles beneath the surface. Now the cells making up the petals of a rose contain a fluid which has the power of absorbing certain of the rays of light, and the light entering the eye after penetrating a short distance below the surface of the petals and coming back has passed through this fluid, and in its course some of the rays of the sunlight have been abstracted from it. Thus the light reaching us is lacking in certain of the constituents of white light—that is, it is colored. White light may be considered as made up of the three fundamental colors, red, green and violet, blended together. The light which has passed through a certain extent of the substance of the rose petals has been deprived of its green and violet portions, and thus the red rays alone reach our eyes. All substances which possess color exercise this power of sifting the rays of light. Light falling on the leaves of the rose bush passes through their superficial layers and is reflected from below the surface; thus it has to traverse certain particles which take from it the red and violet rays and allow the green to pass. The green rays which escape absorption are the only ones which reach our eyes, and we therefore call the leaves green.

When white light passes through a prism it is found that in the band of color or spectrum produced, the blue and violet rays are the most bent out of their original course; they are the most refrangible. The red rays are the least bent. It is found, also, that the vibrations of the ether filling space which produce waves of light are quickest in violet light and slowest in red light. Some substances absorb the quick vibrations more readily and thus appear reddish in color. Others absorb the slower vibrations, allowing the others to pass through, and therefore have a green or blue color.

When a substance is heated its particles are thrown into a state of rapid motion, and soon set up a motion in the ether which, when the vibrations are of a certain rapidity, produces light. If a ball of iron is heated, it first of all gives out radiation consisting of dark rays, which have the effect of producing heat. As its particles become hotter and hotter, and thus vibrate more rapidly, the radiation begins to affect our eyes and the ball glows with a dull red heat. As vibrations of greater and greater rapidity take place owing to the further heating, the ball appears bright yellow, and finally white, when vibrations of all the different rapidities which affect our eyes are given out. In this case it is the motion of the particles or molecules of the heated body which is imparted to the ether, and so produces the effect we call light. Now those molecules which are able to execute certain vibrations and give them to the ether absorb these same vibrations from the ether—that is, absorb certain rays of light. This effect is best seen in the case of gases, and the phenomenon is analogous to that which occurs with sound. A tuning fork or stretched wire which can give a certain note when it is struck is able to take up and absorb the note from the vibrating air around it when that note is sounded in its neighborhood.

It may be noticed that the light from the electric arc when seen near at hand has a distinctly bluish color; but this same light when viewed from a distance appears yellowish, as certain of its rays have been absorbed by the water vapor in the air on its passage to the eye. For a similar reason the sun is now considered to be a blue star; his light, which would appear intensely white, and rich in blue rays especially, if it could be seen from beyond our atmosphere, appears yellowish after it has passed through that atmosphere and has lost some of its most refrangible constituent rays.

The effect of absorption in producing color is seen from the fact that powdered bodies generally appear white. This is accounted for when we consider that a powder consists of particles arranged at all angles, so that the light falling upon it meets various surfaces and is mostly reflected before it has passed below the surface. Thus the white light reaching it is not deprived of some of its constituents by selective absorption, as it would be if it penetrated the substance and was then reflected. In this way powdered red glass appears white. For a similar reason the froth of colored liquids, such as brown ale, appears pure white. The light is reflected from the surface of numerous small bubbles, and does not pass much through the liquid itself. Thus also a cloud is very opaque to light, the light falling on it being reflected at the surface of the numerous globules of water. To this is due the brilliantly white appearance of large fleecy clouds in bright sunshine.

Some substances absorb equally all the rays of light. Such substances, of which soot is an example, appear black. The reason why a flower like a white lily appears white is that the fluid contained in its cells does not absorb one sort of rays more than another, but allows all to pass with comparative freedom. White light then reflected from its surface, or from a little below, is not deprived of any of its constituents, but remains white.

The effect of reflection from internal surfaces, accompanied by absorption in producing color, can be seen by pouring a colored liquid, carefully freed from floating particles, into a white porcelain basin. Light is reflected from the sides of the basin, passes through the liquid, and its color is seen. If now the sides of the basin be covered with some black substance, no light will be reflected from them and the liquid will appear black; no light comes to the eye from the interior, and the surface of the liquid reflects all the rays equally. If next we place in the black looking liquid a white powder like chalk, its color is at once restored, light being now reflected from the interior at the surfaces of the chalk particles.

From the above considerations we can understand

to what causes the color produced on mixing pigments is due. A mixture of blue and yellow paints has a green color because that is the only color transmitted by both pigments. The blue paint absorbs the red, orange and yellow rays, allowing the others to pass through it; the yellow paint absorbs the blue, indigo and violet. Thus green rays alone are permitted to pass through both, and the result is that the mixture appears of that color.

Some substances appear of one color when viewed by reflected light, and another when seen by transmitted light. Thus the light reflected by gold is yellow; but a leaf of gold made so thin that light can pass through it appears of a green color. This appearance of different colors on reflection and transmission is also seen with many of the aniline dyes. The color of the light due to reflection is then made up of those rays which are not admitted at all, but sent back at the surface, together with that light which has been reflected from a certain depth below the surface, and has thus lost some of its constituent rays by internal absorption. The light to which the color is due when the substance is viewed by light which has passed through it, is that which has been deprived of some rays by reflection at the first surface, and again of others by absorption in passing through. Hence the difference of color when viewed in the two different ways.

Variations in color perception no doubt depend on varying sensations in our own eyes, as well as on changes in the light itself. Some curious experiments have been made with a view to testing our different sensations as to color. It has often been noticed that a bright scarlet uniform will appear perfectly white in a good photographic dark room with ruby glass windows. With regard to such effects, Herr H. W. Vogel described recently in Berlin some experiments he had made. He used oil lamps and fitted on to them pure red, green and blue color screens. It was found that when the white light was entirely shut out, no sense of color was perceptible to the observers, and objects in the room appeared of various shades of black and white. He found that when a set of colors was lit up by red light, the red pigments appeared white or gray, and this changed at once into yellow, not into red, when blue was added to the light under which they were viewed. Thus a color was perceived which did not exist in either of the sources of light used. The color sensation produced by a source of light also depends partly on the intensity of the illumination. From these and similar experiments, Herr Vogel comes to the conclusion that our opinion as to the color of a pigment depends upon our perception of the absence of certain constituents from the light reflected from it. Thus a surface which has a red color is only perceived as red by us when light of other colors shines upon it, and we observe its incapacity for reflecting these colors.

When a solution of quinine is viewed in sunlight, a remarkable blue shimmer is noticed extending for a short distance beyond the surface at which the light enters. A similar effect is noticed with many other substances, the color being different in different cases. The phenomenon is known as fluorescence, as it is well observed in the mineral fluorspar, and is due to the fact that light is absorbed by the substance and is again given out as light of a different color. For instance, rays of high refrangibility toward the blue end of the spectrum may be taken in and given out as yellow rays of lower refrangibility. In the case of quinine, invisible rays beyond the violet are absorbed and blue or violet rays are emitted by the solution. In all cases of fluorescence a degradation of the rays takes place; those given out are of lower refrangibility than those which disappear on absorption. By painting a screen with a solution of sulphate of quinine, the spectrum beyond the violet can be made visible, as those vibrations which are too rapid to affect our eyes are changed into others of lower refrangibility, which can be perceived when they fall on the retina. The curious blue color of the solution of quinine extends only a short distance into the liquid, because those rays which are capable of producing it are soon absorbed, and the light which passes onward through the fluid is destitute of such rays. The color produced in cases of fluorescence has a different origin from that of the ordinary surface color of substances, for the rays absorbed do not disappear as light, but their place is taken by other rays of a different sort.

The nature of the vibrations which constitute light still remains mysterious, but great advances have been made in recent years in our acquaintance with these and allied phenomena, and we may hope for still greater accessions to our knowledge in the not distant future.

SOME INTERESTING SPIDERS.

By Prof. FRANZ MÜLLER.

WHO does not know the common shepherd spider that moves about in such ghostly fashion on its long, slender, stiltlike legs? Even as children we were entertained by the grotesque movements of the perfectly harmless creature. This phalangium, although related to spiders and scorpions, has no poisonous weapons, but in place of the poison fangs of real spiders, it is provided with downwardly bent scissorslike palpi, by means of which it catches little insects and carries them to its mouth. It is so well known that it needs no description, but an enumeration of the characteristics which distinguish it from other spiders may be of interest: These are the filiform maxillary palpi terminating in simple hooks, the segmentation of its pea-shaped abdomen, and the small number of its eyes—for it has only two simple eyes. These spiders prefer to spend the day grouped together in dark corners and nooks, and if one of them is touched lightly, it begins to rock or swing its body. This motion is imitated by those near it and soon the whole company are making one another comical bows. Gradually they become quiet again. If touched more roughly or caught, they try to escape, even if obliged to leave behind one or more of their legs. As every one knows, these legs that have been torn off keep up a fluttering motion for hours. This is the result of the decentralization of the nervous system found in all articulated animals, which causes single dismembered portions of the body to show signs of life for a long time; but, in all probability, there is no conscious feeling. One may, for instance, see wasps, May bugs, and other insects running around for days after having lost the whole abdomen, with the viscera, separate legs, wings or other parts of the body of which they have been deprived by being stepped on by a careless pedestrian. Our long-legged phalangium seems not to experience the least pain upon the amputation of one or more legs, and those lost members grow again after the next shedding of the skin, as those of the crab do under similar circumstances. The whitish eggs are laid by the female in damp places, where they can easily be hidden in hollows or cracks.

The swinging or swaying motion adopted by the phalangium when slightly disturbed is not peculiar to it, but is also characteristic of certain other spiders. If a cross spider is approached in warm weather, when in the center of its beautiful wheellike web, or if the web is moved slightly, it begins to swing so energetically that it seems to be a shadow in a rapidly vibrating web. This occurrence can easily be observed in summer in a sunny grove of young trees, where hundreds of these beautiful webs are spread. The object the creature has in making these strange movements it is not difficult to guess, for it must be the same as that of silkworms and other creatures which, when a sudden danger threatens, draw in their heads or take a defensive attitude, which is indicated by the forms and colors they assume. When a cat crooks her back upon the approach of a dog, bristling up her fur and showing her teeth and sharp claws, she does it for the same reason, viz., to frighten the assailant.

A certain spider has been called the "trembling" spider because of this strange motion which it imparts to its dwelling. Several specimens are shown on a somewhat enlarged scale in the accompanying engraving, and as their habits of life are interesting, which perhaps some of our readers may have had as favorable opportunities of observing as I have, we will now study them more closely. This "trembling" spider is also called the "squinting" spider (pholcus, from the Greek pholkos, or squinting), which name was given it on account of the peculiar shape and position of its eight eyes (see lower part of the engraving). It has three large eyes grouped on each side, which differ from those of other spiders in being oval and milky white, with black edges, which gives the appearance of "squinting." The two median eyes are smaller and solid black. The creature is slender and the cephalo-thorax, which carries its long, delicate, hairy legs, seems almost round when looked down upon; its abdomen is rather long and almost cylinder shaped, and its front legs are nearly six times as long as its entire body. Its color is generally a grayish brown.

In regard to the geographical distribution of these spiders, they are found in Switzerland, the Netherlands, France, Italy, Sweden, Hungary, and in some localities in upper and lower Austria. Strangely enough, it and all other spiders of the same family (Phocidæ) are very numerous in East India, and many students have come to the conclusion that this spider came to us from that country, not, it is true, over the land, but across the sea.

The habits of animals of all kinds can best be learned by watching them when free, for in captivity they generally change their ways and do not live as long as if they had been left in their natural state. This seems to be particularly true in regard to spiders. I once had an opportunity, during a stay of eight weeks at Mondsee, of watching nine of these interesting little creatures day after day, and often at night also. Rooms and entries of country dwellings, cellars, garrets, and stables are favorite places of abode for these spiders. Those I watched were in a room which had been used for the storage of furniture, but was temporarily arranged for a sleeping room. They could always be found in the angle formed by the wall and the ceiling, or on the latter, but never far from the wall. Like the shepherd spider, they remain quiet and motionless, apparently sleeping, during the day, and at night they cannot wander very far, for in the morning they are always to be found in the same place. The reason for this is that their nets are there, stretched between rough places in the wall. They are scarcely visible, but upon looking closely, their presence is betrayed by the little flies and particles of dust which have been caught in them. If one of these spiders is touched slightly, it immediately begins its droll swaying motion, and then it can easily be seen that it is holding onto the threads by its long, slender legs. Larger flies are never seen in their webs, and if a live struggling fly is held in the web, the spider is frightened by the violent motion and takes flight. From all that I have been able to observe, the pholcus seems to live entirely on small bipennates which it, like the shepherd spider, catches by spreading its long legs and running over it. One night I saw many tiny flies run along the wall from the open window until some of them reached the domain of my spider. By making a sudden movement to that side of the web where the motion of the threads betrayed the presence of a fly, the spider caught his victim as quick as lightning and sucked its life out.

The swaying motion of one of these spiders is accomplished by placing its long legs on separate threads of the web or on rough places in the wall and moving its body in a circular fashion, and on account of the elasticity of its feet and of the threads of the web, the motion finally becomes so rapid that the body of the spider can scarcely be seen. This performance is most interesting, and a spider never tires of repeating it, whenever disturbed by a slight movement; it takes flight only when roughly disturbed.

PHALANGIUM AND PHOLCUS.

Above at the left is a pholcus carrying its cocoon; at the right the cocoon is suspended. Below at the right a phalangium, at the left a white field showing the position of the eyes of the pholcus.

Both of the spiders which we have been describing practice another ruse, which seems to be quite common to many other creatures higher and lower—that is, feigning death. Once I came upon a pholcus in a vestibule; upon being touched it began to sway, but stopped suddenly as if it had thought of something better, stretched out its legs and lay as if dead. When I wanted to take it up carefully, it freed itself by a sudden jerk and hurried off, leaving three legs behind it. The next day I found it in the same place, and, strange to say, it swung gayly in a circle with its five feet, as if it had suffered no inconvenience. Unfortunately, I could never know whether the lost legs grew again, for, greatly to my regret, it soon vanished forever.

Another characteristic which adds to the interest of watching these spiders is the special care manifested by the female for her offspring. It is well known that spiders place their eggs in a cocoon. In winter one often sees the egg sacs of the cross spider, about as large as a hazel nut, hanging on the wall, in the windows, and in similar places, and in summer wolf spiders can be seen in the fields, in woods, everywhere, running about with egg sacs fastened under the thorax by slender threads. If relieved of their precious burdens, they

run to and fro in great distress. Our spiders' habits are much more interesting. Their comparatively large eggs—twenty to thirty in number—are enveloped in a very delicate loose cocoon through which they show so plainly that many observers overlook its presence altogether, and think the eggs are glued together, and, in fact, at first glance, this appears to be the case, for the whole cluster of eggs looks like a tiny yellowish mulberry; but with the magnifying glass the thin web which holds the eggs can be plainly seen if the egg sac has first been placed in alcohol. The pholcus carries its cocoon until the young fall out, and she probably holds it by means of the palpi, although many maintain that it simply adheres to her. In opposition to this opinion, I would call attention to the fact that a spider which is suddenly thrown into a vessel containing spirits drops the eggs; and also to the following incident which I witnessed and found so interesting that I have illustrated it in the accompanying engraving.

One morning I found one of my spiders out of its accustomed place and without its cocoon. I thought I had another spider before me, when, to my surprise, I saw the eggs near by, hanging by some delicate threads. In order to see them better, I climbed on a chair, but the watchful little creature hurried forward, took the sac and went to its accustomed place. Apparently it had gone out in search of prey, and in the meantime it had hung up its burden in this careful manner.

The development of the young from the egg is most worthy of observation, especially in the case of the pholcus, and the whole proceeding can be closely followed. When the time of maturing comes, the whole cocoon begins to enlarge and to assume a woolly appearance. Upon examination with a microscope, this appearance is explained thus:

The skin of the egg has lost its ball-like shape on account of the development of the embryo in it, which is unfolding and stretching out. In this stage of development, the eggs resemble little pupæ. At last the young slip out, but they do not leave the mother; they hang on the web with the skin that has stripped off, and some of them climb upon the back of the spider, so that the latter looks as if besieged by parasites. After a few days the young spiders spread themselves about the mother spider, which remains perfectly quiet. They hang themselves here and there by means of their long, slender legs, and if one is touched lightly, it shows that it understands how to swing, then its neighbors take up the motion, and presently the entire company of little rope dancers are swinging together.

It is said that when nothing else is at hand, the young spiders eat the pieces of the cocoon, and it is also stated that they sometimes eat one another. This may be the case when they cannot find mites and dust lice, which, however, are seldom rarities where spiders live.—Der Stein der Weisen.

THE NAMES OF CARRIAGES.

CARRIAGES have always been constructed for use, either general or specific, and have acquired names afterward. They have never been built to a name. No statute or common law required names to be chosen first and the vehicles designed afterward, like unto the process of our navy construction.

"Chariot" is the most ancient known name for a vehicle. An Egyptian Pharaoh took Joseph, the abducted son of the patriarch Jacob, out for a ride in one of those kind of springless carts, about 4,600 years ago, because the young chap was a first-class fortune teller.

"Carriage," "wagon" and "coach" are terms that seem to have had their origin in the obscurity of remote times. "Car" and "cart" are apparently derivations of the word carriage, or else "carriage" is the word car inflected with iage, which means use or purpose, and the word chariot is apparently the origin of them all.

The wagon, originally, was a four-wheeled carriage for agricultural purposes, or was first a military invention. The coach was first a vehicle of splendor for people of the highest degree, such as reigning dukes, princes and such, and it was sedition during the middle ages, with unmitigated punishment, for any one else to presume to ride in such a wagon. It is said that coaches were designed during the Roman empire; but it is also thought that their introduction was during that period of Italian history which Shakespeare embellishes with the drama "The Merchant of Venice."

Since prehistoric times a wheelless vehicle often of barbaric splendor, carried by slaves or servants, known by various names, such as "palanquin," "litter," "sedan chair," etc., has been contemporaneous to many kinds of wheeled carriages down to the date of 1850 or thereabout, when it disappeared, except as an ambulance, from all places that do not suffer from a fossilized inheritance of the cobwebbed appliances of bygone generations.

In modern times wheeled vehicles have become much varied by improvements and inventions, and names have had to keep record of those innovations. The greatest modern improvement in pleasure carriages is steel springs. The "gig" is a cart named so from the gigging or jouncing of the new fangled spring when they were adopted. Then came the "C" spring rigs, "elliptic" spring jibs, "side" spring and "platform" spring wagons and carriages, and many named after the style of spring the body is suspended upon.

The "phaeton" has always been considered a gentleman's rig, driven by the master himself. Phoebus always drove the chariot of the sun; but one day young Phaeton took the old man's wagon without asking for it and the heated axles set fire to the axle grease and made a smoke generally, so that the old man had to call him off. Since that reckless effort, gentlemen's own rigs are called "phaetons." Now we have ladies' phaetons. But a lady's phaeton has usually a perched up seat for a driver, or a rumble behind for a "tiger." For ladies generally don't care to hazard themselves, like young Phaeton, or attempt to drive the horses whose necks are clothed with thunder, who snort at the battle afar off and laugh at the shaking spears; or who take the snaffle in their gums and try to upset street cars, lamp posts and quarry trucks with a 145 pound wagon at their heels.

The adaptation of the car and phaeton for hunting purposes brought about the dog cart of the Englishman and the chaise in France. When the hunting grounds of England became the Surrey County hills and moorlands, the Surrey hunting phaeton came in vogue, which lately got the name of a "drag" by the young bloods who affected the slang of insignificance toward it. Those hunting rigs in England always have a receptacle for dogs, guns, ammunition, etc. This locker got the name of "a trap," and the wagon became known in the same slangy way as "a trap." By and by these rigs became "swell" by the multiplicity of horses and the swagger of the swell passengers. And the college towns were taken by the storm of such uproarious swagger when the fad was at fever heat.

By and by this style of wagon became a possible livery rig from being discarded by the youngsters of blue veins; and the people had the satisfaction of junketing in them until they were everyday affairs.

The design reached America and we have the "surrey" of to-day. Now we put a palanquin roof on it and call it a "ladies' surrey," yet goodness knows, the world still wags.

We have now elegantly suspended and equipped phaetons for ladies, styled Victorias, in honor of the lady the first one was created for by the splendid modern art of the carriage designer.

The cabriolette is a similar wagon to the phaeton with an absurd curvature of the body and high driving seat, which puts the jehus up in another tenement from the passengers. It was originally of barbarous design. The American form is much modified and approaches the Victoria in contour. The term cabriolette is supposed to be taken from the absurd curvetings of the Capricornus, or goat.

"Buggy" is one of those words that has lost its significance with its origin.

"Sulky" is thought to be a josh word for a selfishly contrived cart with a seat which forbids any of the neighbors to ask for a ride.

The "democrat wagon" is meant to be a "liberty, fraternity and equality" sort of wagon in which all the passengers sit upon the same plane and are presumed to be of the same social status.

Upon democratic equality the "rockaway" is contrived. It is a purely American family wagon and has no place for flunkies or perched up jehus. Lately designers have begun to put a partition between the driving seat and the passengers and call it a "coupe-rockaway." This makes a fairly good physician's wagon. The old dignified rockaway with the sword case in the back panel was a swagger affair in its day when the republic was young.

The "democrat wagon" is a bucolic affair with movable seats, and it may contain three of them or room for six passengers. It is a sort of social improvement of the farm wagon, and with a wagon top of bent bows it becomes a sort of neighbor-in-law to the rockaway.

The coach is the chief of all the modern wagons and it has assumed more variety than any of them.

When Louis XVI and family tried to escape after the constitutional convention of the notables was about to fizzle out, it was in a coach of barbaric splendor with glass upper panels, called a "Berliner," that he made this historic effort, and the revolutionary people brought him back—"the baker, the baker's wife and the baker's little boy."

The French revolution was initially a bread riot. The people needed whereof to eat. So they did not want the head baker to run away.

That young sport Prince Clarence, son of George III, did not want any glass in his wagon. So he had a sort of "black Maria" all inclosed in wood panels. It wears the name of "The Clarence" in his honor.

The mail and stage coach were ponderous affairs for public use between towns, before the advent of the railroad. The bodies suspended on leather straps, or through braces, from front to rear. This strap was the inception of the side spring of steel. This style of spring was first applied to light wagons or buggies in Concord, N. H., which gave the name of that place to them.

In England the traditionary fox hunts have always called out the surrounding "gentry" when a "meet" was convened. Those gentry usually sent round their "hunters"—as that breed of horses are called—by their servants; and parties of ladies and gentlemen would secure those big mail coaches and with the huntsmen's bugles would make the air resound with the "meet" call of "Tally-ho." When the old coach service died out as the railroads took their place, those great coaches became the property of private persons, and they are still used for hunting and picnic parties, or as they are now called, coaching parties. These coaches are still called "Tally-ho's" from this peculiar service they did. This call is the note of the English blackbird, a species of the thrush.

Another kind of a coach is the landau, named after a place in Germany. It has a leather folding top. It was originally a barbarous looking wagon, but the Parisians made a thing of beauty of it.

Those three kinds of coaches were subsequently cut down to suit individuals. The front seat was cut out and the driving seat was joined to the stanhope pillar which formed the finish in the cutoff body. Then we had the coupe Berliner, the coupe Clarence, the coupe Landau and that English form of coupe known as the Brougham, called after Lord Brougham, who had this kind of wagon contrived so that he could sleep in it between courts while traveling the circuit. For short, these four kinds of carriages are called "coupes."

Sporting vehicles or trotting rigs of all kinds are purely American. No other nation trots horses for sport. There is a greater variety of carriages in the United States than in any other country in the world. —J. G. C., in Varnish.

The etching of wood may be successfully accomplished by coating the surface first with nitric acid, and then with hydrochloric acid, which causes the wood to soften to the depth of about two millimeters. When both of the acids are used together the wood becomes white, while if only nitric acid is used, the part coated becomes of a blackened appearance. In order to prevent the etch from running, the method pursued is to previously treat the other parts with an alcohol lacquer of sufficient thickness or with liquid wax or a mixture of two parts white wax, two parts mastic and one part asphalt, these being melted together and stirred intimately together, then poured with care upon the places which are to be untouched. Some fine specimens of work in this line are produced by French artisans.

SELECTED FORMULÆ.

Steam-tight Cement.—Asbestos powder, made into a thick paste with liquid silicate of soda, is used with great advantage for making joints, fitting taps, and connecting pipes, filling cracks, etc. It hardens very quickly, stands any heat, and is steam tight.

Cement for Hot Water Pipes.—(1) Two parts of ordinary well dried powdered loam and 1 part of borax are kneaded with sufficient water to a smooth dough, which must at once be applied to the joints. After exposure to heat, the cement adheres even to smooth surfaces so firmly that it can only be removed with a chisel. (2) Mix 430 parts by weight of white lead, 520 of powdered slate, 5 of chopped hemp, and 45 of linseed oil. The two powders and the hemp cut into lengths of about ¼ in. are mixed intimately, the linseed oil gradually added, and the mass is then kneaded until it has attained a uniform consistency. It is claimed that this preparation keeps better than ordinary red lead cement.

Cement for Securing Iron into Stone.—The cement is made by melting resin and stirring in brick dust, which must be finely ground and sifted until a sort of putty is formed, which, however, runs easily while hot. In using, the iron is set into the hole in the stone prepared to receive it, and the melted putty poured in until the space is filled; then, if desired, bits of brick previously warmed may be pushed into the mass and a little of the cement thus saved. As soon as the whole is cool the iron will be firmly held to the stone, and the cement is quite durable and uninjured by the weather; unlike lead and sulphur, it has no injurious effect on the iron.

Cement for Mineral Oil.—Boil 3 parts resin with 1 part caustic soda and 5 parts of water. The composition is then mixed with half its weight of plaster of Paris, and sets firmly in half to three-quarters of an hour. It is very adhesive, and excellent for attaching the brass work to mineral oil lamps.—Puscher.

Cement for Mending Coal Oil Lamps.—

Caustic soda	1	drachm.
Resin	3	"
Water	5	"
Plaster Paris	4	"

Boil the soda, resin and water together until homogeneous, then add the plaster. It is then ready for use. It will set in about thirty minutes, is not affected by the oil and but slightly by water.—Ind. Phar.

Aquarium Cement.—

Gutta percha, in shreds	4	oz.
Black pitch	8	"
Shellac	2	dr.

Melt in an iron ladle on a sand bath and stir together. Pour out on a wet slab and roll into sticks.

To Cement Rubber to Iron.—

Gum shellac	1	oz.
Aqua ammonia	10	"

Macerate ten days.—Phar. Era.

Ointment for Chapped Skin.—

Lanolin	3	oz.
Glycerin	4	drachms.
Boric acid	1½	"
Salol	1	"
Hoffman's anodyne	5	"
Menthol	15	grains.
Oil of citronella	3	minims.

Tobacco Habit Cure.—

Gold and sodium chlorate	4	gr.
Strychnine nitrate	2	"
Nitroglycerin	½	"
Fl. ext. digitalis	20	min.
Capsicum	25	gr.
Salicin	100	"
Cinchonidine sulph	100	"

Mix and make 100 pills. One to be taken three times a day.—Med. Bulletin.

Oatmeal Powder.—

FOR USE AFTER WASHING.

Powdered orris root	1	oz.
Oatmeal in fine powder	8	"
Oil of neroli	2	drops.
Oil of bergamot	5	"

Mix the perfumes with the orris root in a mortar, and gradually add the oatmeal, stirring well until perfectly mixed. A little of this powder may be dusted on the skin after washing.

Ginger Ale.—

Jamaica ginger, bruised	3	pd.
Yellow rind of fresh lemon peel	1	"
Capsicum	4	oz.
Alcohol	1	gal.

Of the tincture prepared from the foregoing add 3 ounces to each gallon of sirup.

Gingerette.—

Simple sirup	2	quarts.
Acid solution	2½	ounces.
Soluble essence ginger	1½	"
Soluble essence lemon	2	drachms.
Tincture vanilla	3	"
Tincture capsicum	20	drops.
Caramel	1	ounce.

To one quart of sirup add the acid solution and all the essences and coloring, mix well by agitation; add remaining quart of sirup and shake well together, and if necessary pass through flannel bag, when it is ready for bottling. Color a deep sherry.

Witch Hazel Toilet Cream.—

Quince seed	1	oz.
Glycerin	1	"
Distilled extract witch hazel	32	"
Alcohol	2	"
Borax	15	gr.

Mix the glycerin, quince seed, and extract, and let stand, with frequent agitation, for twelve hours; then strain, add the borax dissolved in small quantity of water and add alcohol gradually.—Bulletin of Pharmacy.

ENGINEERING NOTES.

It is proposed to run a line of railway up Ben Nevis, in Scotland.

From figures recently published at Munich it appears that there are now in central Europe 15,644 gas engines which aggregate 52,694 horse power.

The Dortmund-Ems Canal (Germany), which will probably be opened on July 1, 1897, is a remarkable achievement. At Henrichenburg a hoisting device is being constructed for raising a lock of 70 meters length, with the ship or ships floating in it, to a height of 14 meters. At another place the canal is crossed by a bridge of 15 meters width and 70 meters length.—Uhland's Wochenschrift.

The first half of the Congo Railway has been completed. There are eight stations along this section, whose length is 180 kilometers. Whites have to use first-class carriages, the fare for the whole trip being 233·50 francs (about $47) and 350 francs for the round trip. Natives have to take open second-class carriages, the fare being 23·50 francs for the single trip and 35 francs for the round trip.—Uhland's Wochenschrift.

Pear carbon, which is almost pure, is now used in England for carbonizing armor plates. The carbon is made into a plate of the size and shape of the steel plates to be hardened, and is then forced into the surface of the metal by hydraulic pressure. It is asserted that in this way a hardened plate can be produced in one-third the time usually taken, that it will be harder on the face and tougher in the back, and will give greater resistance than anything hitherto produced.

From some experiments made to determine the best angles for the heads of countersunk rivets for ships' plates, Prof. Weighton concludes that for ¼ in. plates the countersink should not be less than 56°, and even a greater angle would seem to be not amiss; and second, that for ⅝ in. plates the countersink should not be less than 35°. For other thicknesses the angle of countersink would be in proportion, and the following would be about the angles proper for the different thicknesses: ¼ in. plate, 56° angle of countersink; ⅜ in., 45°; ½ in., 35°; ⅝ in., 26°.

In a recent report made to the Canadian Pacific Railroad Company by one of its engineers of some tests of various kinds of steam lagging, the following table was included, showing the loss of power that has been found to take place from uncovered pipes filled with steam at 75 pounds gage pressure:

2 in. pipe,	1 h. p. loss for every	132	ft. of length.
4 " "	1 " " "	75	" "
6 " "	1 " " "	46	" "
8 " "	1 " " "	40	" "
12 " "	1 " " "	26	" "

About 90 per cent. of this waste, it was added, can easily be prevented by a proper covering of the pipes. When it is considered that this loss occurs at the comparatively low pressure of 75 pounds, it is apparent that with steam at 130 pounds and 140 pounds and higher, the loss becomes very serious.

The total consumption of coal on Indian railways during 1895 was 6·32 per cent. greater than in 1894. The quantities of English and Indian coal used increased by 13·87 and 5·41 per cent. respectively. The total consumption of patent fuel increased by 52·08 per cent., while the consumption of coke and wood decreased by 12·53 and 8·29 per cent. respectively. The consumption per train mile on the East Indian Railway was 57·11 lb., and per engine mile 47·49 lb.; on the Indian Midland 49·60 and 44·70 lb.; on the Northwestern State 45·39 and 40·37 lb.; on the Great Indian Peninsular 44·24 and 30·03 lb.; on the Madras 47·83 and 40·62 lb.; on the Southern Mahratta (meter) 33·89 and 31·31 lb.; and on the Rajputana-Malway 34·65 and 30·32 respectively. Various kinds of coal are used, but all the above figures have been reduced to a comparable basis, viz., Kurhwibee coal, which, as compared with Welsh steam coal, is as 1:0·80.—Railway Engineer.

The railroad across Siberia is in working order from St. Petersburg to a point beyond Krasyonask, where the arrival of the first train from European Russia the other day was the subject of much public rejoicing. By next year the relatively small piece of road to Irkutsk will be open to traffic, which will mark the completion of the entire western and by far the largest moiety of the transcontinental line. East of Irkutsk all the labor and material will be supplied from the eastern terminus at Vladivostok, on the Pacific coast, and a considerable portion of the eastern section of the road is already constructed. In fact, if the work is carried on at the present rate of speed, it is probable that the entire line may be completed in 1898, instead of 1905. Meanwhile the Chinese government has granted a concession to a Franco-Russian company to construct a railway through Manchuria, connecting with the Russian-Siberian line at Stretensk and striking southward to the coast on the Pacific.

The vexed question in the theory of fluid friction, whether finite slipping does or does not take place at the surface of a solid in contact with a liquid, forms the subject of a contribution by Dr. Antonio Umani in a recent number of the Nuovo Cimento. The experiments were conducted in the physical laboratory of the University of Parma, the apparatus used consisting of a cylindrical box filled with mercury and suspended by a torsion fiber. In one series of experiments the sides of the box were nickel plated, so that the mercury did not actually wet the metal; in another series the mercury was made to bathe the sides of the box by thoroughly amalgamating the latter. In the former case the presence of a film of air between the mercury and nickel was obviated by filling the box in vacuo. The observed values for the logarithmic decrement of the amplitude of the oscillations were found to differ in the two series of experiments by an amount which, Dr. Umani considers, indicates finite slipping between the mercury and the box when the latter is nickel plated. The author further proceeds to calculate the internal coefficient of viscosity of mercury from the results of his second series of experiments and obtains the value $n = 0·01577$ C. G. S. unit at temperature 10 degrees Cen. Warburg, employing Poiseuille's method, had previously, Nature says, obtained at temperature 17·2 degrees Cen. the value 0·01602.

ELECTRICAL NOTES.

A narrow gage light electric railway is to be constructed between Sterkrade, Oberhausen and Merderich, Prussia.

The municipal authorities of Turin have placed a contract with a Belgian company for the conversion of several of the tramways in the town into electric lines.

A company has been formed at Ojebro, Sweden, for the purpose of purchasing four waterfalls in the neighborhood, the power of which it is proposed to use for electric lighting of the towns of Vadstena and Skeinige, and for the working of some mills.

The great wheel at the Earl's Court exhibition is now put to a novel use for advertising purposes, says the English Electrical Review. The name of a weekly paper in letters 30 feet high has been inscribed by means of electric lamps between the outer and inner circles, the light being given by 260 incandescent lights of about 30 C.P. The letters are in gas piping, the electric wires being inside, and issuing through holes to feed the lamps. It is claimed that this advertisement will be visible five or six miles away.

The Hungarian government has authorized the making of an electric railway between Budapesth and Trieste by the Société de l'Industrie Electrique de Genève, which has deposited caution money to the amount of 3,000,000 florins in the Hungarian treasury. Starting from Budapesth, the line is to follow the shore of Lake Balaton, and then pass by Balaton, Fured, and Csakathurn, to terminate at Trieste. There are no considerable engineering difficulties to be overcome in this long line.

A pretty application of electricity has been made in the photography of instantaneous splashes. The pictures were taken each with an electric spark, giving an exposure less than 0·000001 of a second. The spark could be so timed as to pick out any desired stage of the splash within limits of error not exceeding, as a rule, about 0·00002 of a second. In this way the progress of a great variety of splashes has been followed in detail. Among the points specially illustrated were the formation of bubbles, and the manner in which the conditions of the surface affected the disturbance produced by the entrance of a solid sphere.

For the past three months an interesting isolated plant has been in operation at Messrs. J. Snook & Company's of Nottingham, says the Electrical Review. This plant includes a 90 horse power water tube boiler, two 25 horse power engines, one 500 light dynamo, four 6 horse power electric motors, five electric fans, six electric irons, etc. The whole of the operations of lighting, ironing, heating and ventilating in this establishment are carried on electrically. The cost of generating power for all these varied operations during the past three months has been very carefully noted, and after allowing 10 per cent. for depreciation and all charges for wages, coal, water, oil and sundries, the cost of generating amounts to one penny per unit.

The General Electric Company, of New York, recently gave out information from its mining and power department showing the growth in the use of electric power, and also its economy and efficiency. The figures which represent horse power refer to electric power apparatus only:

	1892.	1893.	1894.	1895.
H.P.	13,719	18,762	42,379	46,727

In 1896, the missionary work of the past four years began to come to rapid fruition. From January 1 to July 31 the total horse power of the apparatus amounted to over 48,000 h.p. During the same period, in 1895, the aggregate orders amounted to 25,737 h.p. From August 1 to August 18 the total amount of power apparatus ordered during 1896 was increased to the respectable figure of 62,164 h.p.

The Pelton Water Wheel Company, of San Francisco, Cal., some time ago sent a power plant to Mexico which has some features of unusual interest, says the Engineering and Mining Journal. The plant embraces two 67 inch three nozzle Pelton wheels having a capacity of 700 H. P. running under a head of 100 feet. This station operates a jute factory located at Barrio Nuevo, in the State of Orizaba. These wheels are connected to four electric generators, and the power transmitted to the factory 1¼ miles distant. No line or countershafts are used, but every machine is run by a separate motor varying from 1 to 20 H. P., as required. Pelton regulators are attached to the wheels, which give a uniform speed under all variations of load. This is the first factory in the world on a large scale to be run exclusively by electricity with an entire absence of shafts and belt connections. When it is considered that some 30 per cent. of the power in any plant of this character is absorbed by shafting and belts and that constant expense is necessary in maintenance, the advantages of such a direct connection, where electricity is the means of power, are most apparent.

One of the cheapest ground returns that can be built for electric roads may be constructed of old rails. Flat rails are the most convenient for the purpose and are usually the most available. They may be readily laid between the rails. It is necessary, however, in order that the rail thus laid shall materially reduce the resistance of the return circuit, that it be exceptionally well bonded, otherwise there will be little gained. One point may be noted as being extremely favorable in this class of bonding. The rail is not subject to continuous jar, as in the case of rails doing, at the same time, mechanical service, still the joints are subject to the gradual motion of expansion and contraction. The bond must, therefore, be flexible, or it will gradually work loose. If such a feeder were laid with its joints staggering, those of an active rail and cross bonded thereto, the failure of a bond on either rail would be provided for. By drawing a sketch of the two rails and the bonds, it will be seen that by staggering the rails each joint is bridged by a rail, the path having four bond joint. If the joints are opposite, the number of bond joints in this reserve bridge is increased to six. The use of old rails for this purpose would seem to be very advisable, being both economical and durable. The electric continuity of the bond may be preserved from corrosion by embedding it in an asphaltic compound.—Electrical World.

MISCELLANEOUS NOTES.

Two and a half tons of Chasselas grapes were taken from the King's vine at Fontainebleau this year.

The directors of the Aussig-Teplitz Railway publish the statistics of brown coal production in Bohemia. The total production in the two districts, Elbogen-Falkenau and Teplitz-Brüx-Komotau, was 14,700,000 metric tons. The value of the coal varied between 1·88 kreuzer (75c.) and 1·36 kreuzer (62c.) per ton. The total production was 740,000 tons greater than in 1894.

There are many old house doors in Holland which have a very curious use. There is one door which is never opened except upon two occasions—when there is a marriage in the family or a death. The bride and bridegroom after their wedding enter by this door, after which it is nailed up or barred until the next marriage or death occurs, when it is opened, and the bride or corpse enters or is removed by this portal.

The Brooklyn watchcase companies having amalgamated, a new factory has been erected for their accommodation. The old ones, says the Philadelphia Ledger, are being pulled down, and trusted employes have been at work scraping the floor and digging the dirt out of the cracks. The scrapings and dirt have been placed with smelters, and gold worth nearly $7,000 has been recovered. The work has not been completed, and the consolidated companies hope to recover gold worth at least $3,000 more before they get through with the scraping.

Two of the most wonderful automata now working within the limits of the United States, remarks the Argosy, are those used by the government for counting and tying postal cards into small bundles. These machines are made in Connecticut and the two are capable of counting the prodigious number of 500,000 such cards in ten hours, and wrapping and tying the same in packages of twenty-five each. In this operation the paper is pulled off a drum by two long fingers which come up from below, and another finger dips into a vat of mucilage and applies itself to the wrapper paper in exactly the right spot. Other parts of the machine twine the paper around the pack of cards, a thumb presses over the mucilage pot and the package is thrown upon a carry belt ready for delivery.

A statistician has learned that the annual aggregate circulation of the papers of the world is calculated to be 12,000,000,000 copies. To grasp any idea of this magnitude we may state that it would cover no fewer than 10,450 square miles of surface, that it is printed on 781,240 tons of paper, and, further, that if the number 12,000,000,000 represented, instead of copies, seconds, it would take over 333 years for them to elapse. In lieu of this arrangement we might press and pile them vertically to gradually reach our highest mountains. Topping all these and even the highest Alps, the pile would reach the magnificent altitude of 490, or, in round numbers, 500 miles. Calculating that the average man spends five minutes reading his paper in the day (this is a very low estimate), we find that the people of the world altogether annually occupy time equivalent to 100,000 years reading the papers.

Years ago, when cycloramas were all the rage in European cities, De Neuville and Detaille collaborated in painting the enormous panoramic picture of the battle of Rézonville. The work was exhibited in several cities; but finally it became a back number, the receipts fell off, and it was decided to sell out. A shrewd speculator bought the canvas, and cut it up into more than a hundred small pictures. Two of the most dramatic large groups were preserved, showing "The Council of War between General Bourbaki and Marshal Canrobert" and the "Death Ride of Rézonville." These two compositions have been bought by the French government for the historical museum at Versailles, at a price which is almost equal to that given for the entire panorama by the speculator. There remain 135 pictures of various sizes and degrees of importance, from single heads to large groups, which are either sold or to be sold.—Boston Transcript.

India, says a contemporary, would scarcely be looked to for an example of forest preservation, but that country has perhaps the finest national forest policy of any in the world. Before regulations for the conservation of growing timber had been devised and put in force, its forests had been consumed as recklessly as those of the United States, and that is putting the case as strongly as is necessary for emphasis. Fires destroyed, timber for use was cut lavishly and without regard to economy, and the forests were disappearing under careless treatment. Through the present policy India has placed 80,000 square miles under permanent regulation, while 50,000 other square miles are in process of settlement. A large number of trained men now constitute a force to protect the forests. The revenue from these reserves is expected to equal the expenditure for the entire preservative machinery. The product of the forests brings in a liberal and growing surplus. This policy has been in operation for thirty years and has been a great success.—Northwestern Lumberman.

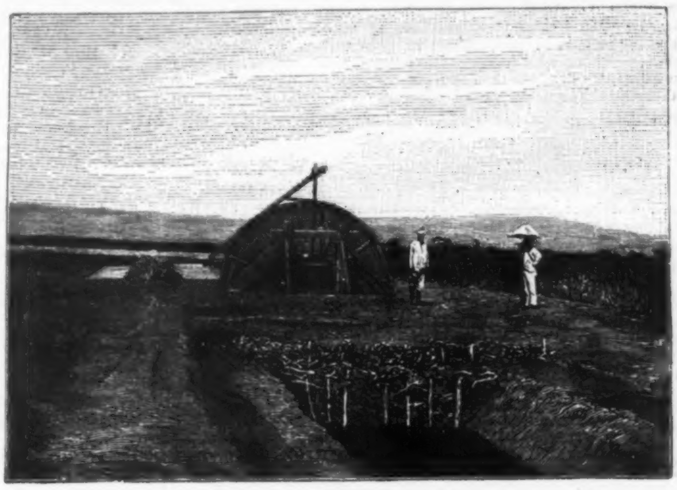
"Indurite" is the name given to a smokeless powder invented by Dr. Monroe, of the American Chemical Society, made by purifying dried military gun cotton, by extracting it with hot methyl alcohol in a continuous extractor. When this is completed, the insoluble, nitrated cellulose is again exposed in the drying room. The highly nitrated cellulose is then mixed with a quantity of mono-nitro-benzine, which scarcely affects its appearance and does not alter its powdered form. The powder is next incorporated in a grinder by which it is colloidized, and converted into a dark translucent sheet or mass resembling India rubber. The sheet is now stripped off and cut up into flat grains or strips, or is pressed through a spaghetti machine and formed into cords, either solid or perforated, of the desired dimensions, which are cut into grains. Then the granulated explosive is immersed in water boiling under the atmospheric pressure, by which the nitro-benzine is carried off and the cellulose nitrate indurated, so that the mass becomes of light gray to yellow color, and as dense and hard as ivory. It is by this physical change in state, which can be varied within limits, that the material is modified from a violent rupturing explosive to a slow-burning propellant.

COLONY OF DIEGO-SUAREZ IN MADAGASCAR.

Far from being in jeopardy, the colony of Diego-Suarez is daily assuming a greater importance. In order to make this colony very intimately known to the readers of this journal, I propose to take them thither.

No description can render the aspect of a country as faithfully as an image, as a photograph or a series of photographs taken upon the quick. I am, therefore, going to show our readers a series of views taken by me during the short stay that I recently made in Diego-Suarez, and which may make them think that they have been transported for a few instants to the districts of the northern part of Madagascar. They shall see and judge of it.

DIGGING CANALS IN THE SALT DISTRICT.



ELEVATION OF SEA WATER.

The shore boats that go to take passengers off the steamers can land at any one of three docks, that of Messageries, that of the local service or that of the directorship of the port.

All those who have visited Diego-Suarez are acquainted with the pavilion of the directorship of the port and with Lieutenant of the Port Geffroy, one of the most amiable and sympathetic functionaries of the colonies. After landing, one walks along the wharves in order to enter Republic Street—one of the streets of the lower city that will soon have to disappear in order to permit of the construction of large arsenals and graving docks in this privileged locality.

Near the middle of Republic Street stands a legendary tree, the tamarind, a tufted tree without its equal in the colony and which formerly performed the function of official journal, the acts of the administration having been posted under its shade and thereby promulgated.

NATIVES AT THE FOUNTAIN.

Upon ascending to the upper city, to the Plateau, as it is called, through various abrupt and pebbly roads, we reach Flacourt Street, which begins at the residence of the administration, constitutes the great artery of the Plateau, and is prolonged by the Antanamitara and Amber Mountain routes. The aborigines do not dwell on one side, but their huts are everywhere situated upon the confines of the city, and, by order, are covered with corrugated sheet iron. In the country, the natives may build as they please and are free to adopt any kind of roofing that suits them.

These natives do not belong to a single race. The territory of Diego, formerly desert, has become gradually peopled through borrowing the elements of its prosperity from neighboring countries. There have come hither large numbers of Saint-Mariens and perhaps a larger number still of Saint-Mariennes, then Comorians and Malgashes of all origins—Betsimisarakas, Sakalaves and Hovas; but, among the Malgashes, the most valuable to the colony are the Antaimoros, who come from the south of Madagascar to hire themselves as laborers among the colonists for tilling the soil and for internal service.

As Antsirane is not as yet provided with a pipe line to lead water in abundance into the city and the houses, the natives employed as domestics have to go to obtain spring water. They are met with at all hours in the city carrying "zincs" full of water. In lieu of pails, they use empty petroleum cases. The women carry these upon the head, while the men carry two of them suspended from the extremity of a stick supported by the shoulder.

The colony is favored with several rivers that are capable of supplying a regular pipe line, especially Caiman River, the water of one of whose upper branches, the Lalandriana, will soon be impounded.

The busiest of the rivers is that of Maques, which debouches near the village of Anamakia, to the south of the port of Nièvre. Upon the left bank of this are situated the wharves of the salt works and of the manufactory of preserved meat.

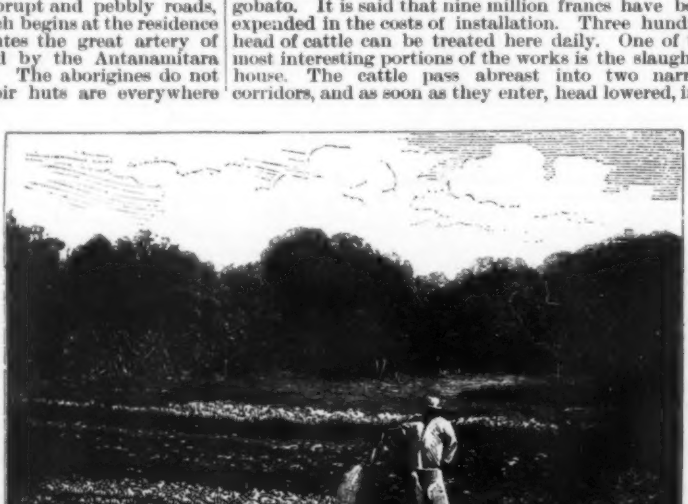
It has sometimes been said that the colony of Diego-Suarez is destitute of trees and vegetation, but this is an error and a calumny, as our photographs prove. There are magnificent pasturages that permit of keeping large droves of cattle. These latter furnish meat for export and highly esteemed hides, and are sometimes exported alive. They serve also as draught animals for hauling carts, and a certain number, besides, have been trained as beasts of burden.

The colony also possesses a few asses and horses. The breeding of the horse, which was tried, but which was unfortunately interrupted by the last war, is an experiment to be resumed, and everything leads to the belief that it will prove successful, since the climate of the colony is very favorable for acclimation of the equine race.

Two important industries are worthy of remark—that of salt and that of preserved meat.

Very extensive salt works have already been installed upon the Main and Maques Rivers and in the plains of Betaitra. The salt that has already been collected is of good quality and fine appearance. Its shipment will assure the port a constant business. The manufactory of preserved meat is situated at Antomgobato. It is said that nine million francs have been expended in the costs of installation. Three hundred head of cattle can be treated here daily. One of the most interesting portions of the works is the slaughter house. The cattle pass abreast into two narrow corridors, and as soon as they enter, head lowered, into

THE BAOBAB.



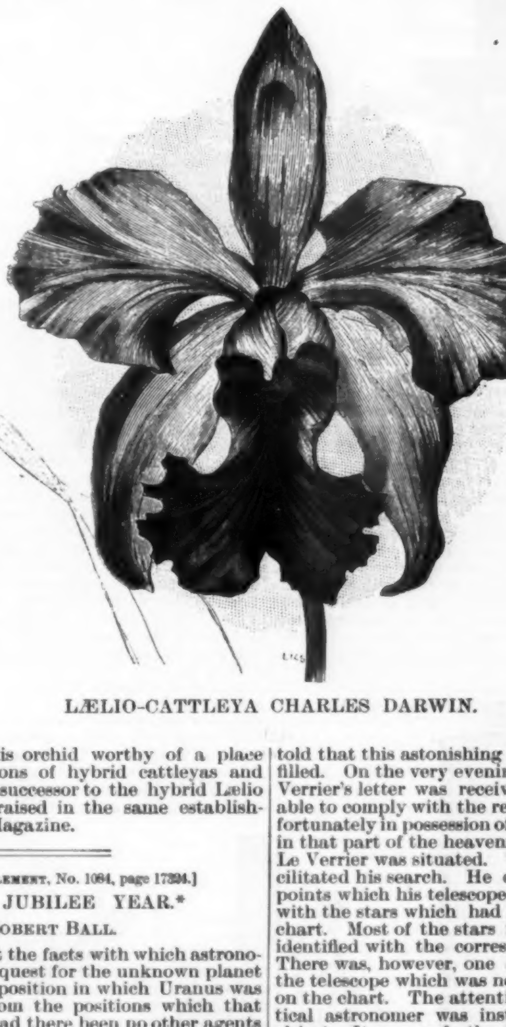
MARKET GARDENING BY THE CHINESE.

the compartment that follows, a man strikes the lower part of the head of each animal with a club. The blow is almost always mortal. After the animal has been skinned and quartered, it is carried to a cold storage chamber and afterward boiled, put in cans and shipped.

Curiosities abound in Diego-Suarez, and there are all kinds of them. If we desire a natural curiosity, we have the baobab, the largest tree known, the branches and roots of which are so entangled and confused as to give the illusion of a forest in miniature, and which reaches prodigious dimensions (about a hundred feet in height and seventy-five or a hundred in girth). If we desire an example of curious habits, we may visit the cemetery of Antsirane, where upon all the tombs of the natives we shall see objects that are not found in our own cemeteries—such as glasses and bottles. The latter are empty, the relatives having drank to the dead and left a mark of their good action behind. If we wish a curious souvenir of the last war, we have a cannon captured from the Hovas upon the colonial territory at Point 6. With this plaything, the Hovas fired at us at 1,200 yards, but killed no one.—H. Mager, in Le Monde Illustré.

LÆLIO-CATTLEYA CHARLES DARWIN.

THIS is a strikingly beautiful hybrid, the result of crossing Lælio-cattleya elegans Turneri with the pollen of Cattleya maxima. It first flowered in the collection of C. J. Ingram, Esq., Elstead House, Godalming, and was raised there by Mr. Bond, the gardener, by whom it was exhibited at the Royal Horticultural Society meeting, August 27, 1895, when it received an award of merit. The flower has the general shape of the seed parent, but the sepals and petals are rounder and broader; the color is light rosy purple. The broad, very undulated front lobe of the lip is brilliant amethyst purple, the side lobes lighter, tipped with the coloring of the front lobe, and shading to yellow toward the center of the throat. The pseudo bulbs are intermediate between the two parents, clearly indicating the influence of the pollen plant. Its distinct coloring should make this orchid worthy of a place among the finest collections of hybrid cattleyas and lælio cattleyas; it is a fit successor to the hybrid Lælio cattleyas Ingrami, also raised in the same establishment.—The Gardeners' Magazine.



LÆLIO-CATTLEYA CHARLES DARWIN.

[Continued from SUPPLEMENT, No. 1084, page 17324.]

NEPTUNE'S JUBILEE YEAR.*

By Sir ROBERT BALL.

LET it be observed that the facts with which astronomers had to deal in their quest for the unknown planet were simply these. The position in which Uranus was actually found differed from the positions which that planet would have held had there been no other agents acting upon it except those which are already known. Accordingly two mathematicians, Urbain J. J. Le Verrier, in France, and John Couch Adams, in England, undertook to investigate the position of a conceivable planet which should be capable of producing precisely these disturbances in the motion of Uranus which had actually been observed. It need hardly be said that the solution of this question involved refinements of mathematical research which could not be here reproduced. I may, however, indicate an outline of the methods which had to be pursued in this extraordinary investigation. First, some well considered guess or assumption had to be hazarded as to the distance from the sun at which the supposititious planet might be likely to revolve. Its orbit should certainly be presumed to lie outside that of Uranus, and from a certain curious law which governs the distances of the other planets from the sun with some regularity, it was possible to anticipate what the distance from the sun of an additional planet revolving outside Uranus reasonably might be expected to amount to. The weight of the hypothetical planet could also in the first instance be only estimated rather vaguely, but the assumptions being made, it became possible to calculate the effects which such a body, if it really existed, would produce upon Uranus.

* From the New York Sun.

It could hardly be expected that a first attempt of this kind would provide a satisfactory explanation of the irregularities in the motion of Herschel's planet, but by making successive trials in which the unknown planet was placed at different distances from the sun, and assumed to have different magnitudes, light gradually dawned on the subject. Both of the illustrious astronomers, Le Verrier and Adams, each pursuing his researches independently of the other, came at last to the conclusion that it was quite possible to determine the whereabout of the unknown planet from the study of its action reflected, so to speak, in the movements of Uranus. Indeed, it is a most remarkable circumstance that the two investigators should have concurred not only in determining the track of the unknown planet, but even in ascertaining the very spot in the heavens which the unknown object occupied. When Adams and Le Verrier found that this hypothetical body did exercise precisely that kind and degree of attractive power upon Uranus which would provide the necessary explanation of its perturbations, their confidence that the hypothetical body must have a veritable existence rose to absolute certainty.

Le Verrier's calculations having been completed, he not only ascertained the track in which the unknown planet moved and the mass of that body, but he was able to learn its movement through the heavens, so as to know the place among the stars which it occupied day after day. At last he felt so confident that this planet could now be detected by the telescope that on the 18th of September, 1846, a day from henceforward to be memorable in the annals of astronomy, Le Verrier wrote to Dr. Galle, astronomer at the Berlin observatory, requesting him to direct his telescope on a particular spot of the sky which was carefully indicated, and there, said Le Verrier in effect, "you will see a planet which I have not seen, and which no human eye has ever seen, but which, nevertheless, must lie in that spot, because my calculations have pointed out the necessity for its existence."

It may sound almost like a romance when we are told that this astonishing prediction was literally fulfilled. On the very evening of the day on which Le Verrier's letter was received at Berlin, Dr. Galle was able to comply with the request made of him. He was fortunately in possession of an accurate chart of the stars in that part of the heavens where the spot indicated by Le Verrier was situated. This circumstance greatly facilitated his search. He compared the several bright points which his telescope showed him in the heavens with the stars which had been marked down on the chart. Most of the stars in the sky could be readily identified with the corresponding stars on the chart. There was, however, one starlike object in the field of the telescope which was not represented by any point on the chart. The attention of the experienced practical astronomer was instantly concentrated on this object. It was perfectly clear that the orb he was now looking at could not have been visible to the painstaking astronomer who had some years before been studying that part of the sky and taking note of all the stars it contained, with a view to the preparation of the chart.

There seemed to be only two possible suppositions to account for the discrepancy between the chart and the sky. One would be that the object in question was a star which had sprung into visibility at some period subsequent to the observations made for the preparation of the map. The other supposition would be that the suspicious object was a veritable planet, that is to say, a wanderer over the heavens, which had been in some other part of the sky at the time when the chart was being made, but which had since moved into the position where it was now met with in September, 1846.

Closer examination showed that the latter was the true interpretation of the new object. It was found to be in motion; it was, therefore, indeed a planet. Subsequent investigations, with high magnifying powers on the telescope, disclosed that this new member of the solar system possessed a characteristic by which a planet can often be distinguished from a star. No amount of magnifying power will ever exhibit a star otherwise than as a brilliant point of light. Such an object never presents the appearance of a disk with perceptible area and a circular or oval outline. On the other hand, a planet may frequently be observed to show a distinctly marked disk. This test was here applied, and the new object was presently shown to possess the planetary figure, and thus its true character was illustrated in another way.

The scientific world stood amazed at this astonishing discovery. In any case, to have added yet another magnificent planet to the sun's retinue would have been a notable achievement. But the circumstances under which this planet was brought to light made the incident mark an epoch in the history of the human intellect. Here was a superb planet, eighty times larger than the earth, discovered not by a mere accidental survey, but in consequence of refined mathematical anticipations, which illustrated in the most emphatic manner the truth of the law of universal gravitation. The name of Le Verrier was immediately elevated to a pinnacle of renown higher than that attained by any mathematical astronomer since the days of Newton.

It presently appeared, however, that the fame of the discovery of Neptune was not to be solely the property of Le Verrier, but that it would have to be shared with a young English mathematician, J. C. Adams, who had recently taken an exceptionally brilliant degree at Cambridge, and had also, as we have said, discovered the planet by calculation ere it had ever been telescopically seen.

Adams had also, like Le Verrier, provided instructions for the practical astronomer by which the telescopic search for the planet might be undertaken. Prof. Challis, of Cambridge, commenced to search for the planet in accordance with the calculations of Adams, but he was unfortunately not provided with that special appliance for facilitating such a research which was available to Dr. Galle at Berlin. The Cambridge observer had not yet received a copy of that star chart without which the task of discriminating the planet from among the hundreds of adjacent stars involved an arduous and tedious piece of work. Prof. Challis did, however, manfully undertake the laborious duty of instituting a careful survey of the region. We now know that in the course of his work he had, on more than one occasion, unwittingly observed the planet Neptune, so that there cannot be the least doubt that the process which he was pursuing must necessarily in due time have resulted in complete success. But while Challis was engaged in this laborious work news reached Cambridge of the discovery of the planet which had already been effected at Berlin. A considerable controversy thereupon ensued. The French nation claimed for Le Verrier the credit of the discovery of Neptune, and was at first inclined to deny to Adams any share whatever in the immortal achievement. They urged that Le Verrier, quite unconscious of the labors of Adams, had completely worked out the position of the planet, and in consequence of that work, and solely in consequence of it, the planet had been telescopically discovered at Berlin. Those who put forward the claims of the English mathematician urged the undoubted fact that the calculations of Adams were really prior to those of Le Verrier, though it was admitted that the optical discovery by Dr. Galle anticipated the discovery which certainly would have been made by Challis when he had completed and compared his observation at Cambridge. The English claim demanded that the fame of the discovery of Neptune by mathematical research should be shared between Le Verrier and Adams.

Gradually this claim has come to be almost universally recognized as a just one. It is true that certain French writers occasionally speak of the discovery of Neptune as simply due to Le Verrier, but impartial judges generally refer to it as the result of the concurrent labors of the French and the English astronomers.

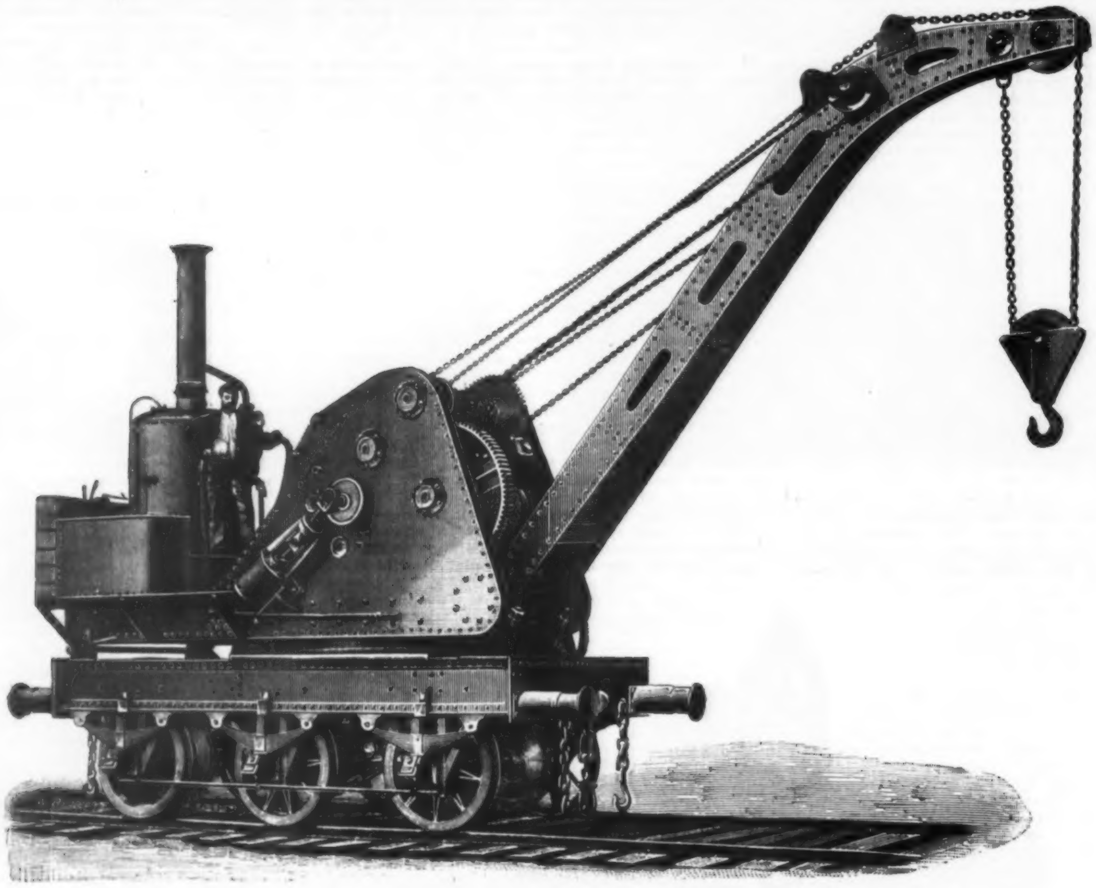
There can be no doubt that even if Le Verrier or Adams had never lived Neptune would in the course of the last fifty years have been discovered in some other way. We frequently read in the papers announcements of the detection of an additional planetary member of our system, but no one attaches to such achievements more than a very small fraction of the significance that must ever be attached to the discovery of Neptune. These small planets are usually discovered by diligent comparison of the stars in the sky with the stars on the chart, and whenever a new object is thus brought under notice it is carefully looked after. There can be no doubt that Neptune would in course of time have been found by this simple survey work, and though its detection would have been a great reward to the diligent astronomer who was so fortunate as to have first dropped upon it, yet it would have been a matter of much regret had Neptune been thus picked up, instead of having been the object of that wonderful mathematical triumph by which indications were given of the exact spot in which the search was to be made. Indeed, as a matter of fact, Neptune had once been very nearly discovered in what may be described as an accidental manner before either Adams or Le Verrier was born.

Astronomer Lalande records in his great celestial catalogue a certain "star" in a certain place on May 10, 1795. Subsequent inquiries instituted by Adams showed that this object was not a star as Lalande thought, but that it was really the planet Neptune. A reference to the original manuscript observations of Lalande brought circumstances of much interest to light. It appears that the astronomer had observed this object on May 8 as well as on the date two days later, but as his observations showed a different position on the 10th from that which he had set down on the 8th, Lalande concluded that the latter was erroneous. We now know that the discrepancy in the two positions was simply due to the movement of the planet in the interval. Little did Lalande dream that a superb discovery had lain so nearly in his grasp, but we cannot regret that he did not make it. Had he done so, it would have been what we may relatively describe as a mere accidental achievement. We should have been deprived of the most glorious illustration science has yet given of the principles of theoretical astronomy.

MM. W. SCHLOESING, the younger, and Jules Richard have recently read a paper in regard to researches upon argon in the gas within the swim bladders of fishes.

TEN TON LOCOMOTIVE STEAM CRANE.

WE illustrate on this page one of four ten-ton steam locomotive cranes recently constructed by the Southgate Engineering Company, Limited, of New Southgate, N., for one of the Indian railway companies. It is made to run on a five feet six inches gage railway, that of the line, and is provided with spring buffers, so as to run in train with their rolling stock. The crane is self-propelling, and the traveling gear is made so that it can be thrown out of action when the crane is running with other vehicles. A friction clutch is introduced with the gear wheels on the axles, so that when the crane is self-propelling any excessive shock which it may receive will be dissipated in the clutch before it reaches the gearing. The gearing of the crane throughout is of cast steel, and the cheeks are made of mild steel plates stiffened round the inner edge with angles. The jibs are curved in order to give the largest possible amount of head room; they are composed entirely of steel plates and angles with tee stiffeners. All the various motions of the crane are controlled by means of friction clutches which may be put into action or taken out while the crane is running. All the bearings and loose pinions throughout the crane are bushed with gun metal. These cranes were made by the above mentioned company in their works at South Road, and erected and tested to twenty-five per cent. more than their nominal power in all their motions at their new railway works recently completed at New Southgate. We are indebted to London Engineering for the cut and copy.



TEN TON LOCOMOTIVE STEAM CRANE.

THE TABOR MODIFICATION OF WATT'S INDICATOR.

THE Tabor indicator itself is not new. We refer to it at the present time in order to make known an ingenious mechanism that has recently been adapted to it and that renders it very easy to throw the paper drum into gear as well as to manipulate the instrument.

It is well to recall the fact that the lightness and sensitiveness of this indicator render it particularly applicable to high speed engines. The style takes on very precise rectilinear motions. Its lever is guided at three points. At the extremity opposite the pencil it is connected with a rod pivoted upon the head, B, of the steam cylinder. Another rod of this lever is jointed with the piston rod of the cylinder. Finally, in front of this rod, the lever carries a small loose roller, that plays freely in a curved slot formed in one of the sides of the guiding frame, which likewise is mounted upon the cylinder head.

Owing to the form given this slot, the two rods remain parallel in all the positions of their common lever, and the pencil, which is always in the prolongation of the line passing through their lower joints, takes an absolutely rectilinear motion. Not the least deviation is observed, even when the roller is moving from one extremity of the slot to the other. The weight of the movable parts is so feeble and the friction so slight that the diagrams undergo no distortion, even at high speeds. The pressure of the pencil against the drum is regulated by the set screw, C, that is made to project more or less from the base of the frame, so that upon its abutting against the stop, D, the pencil shall touch the paper lightly.

The spring of the piston is of the duplex type. The piston acts with ease by reason of the ball and socket joint of its rod. Four circumferential grooves assure the tightness of the piston, which plays in a tube that is assembled, at the bottom only, with the cylinder properly so called, and leaves for the rest of its height an annular space that the leakage of steam traverses in order to escape into the atmosphere through orifices in the cylinder. The latter has thick and strong sides, so as to protect the internal tube.

The mechanism that actuates the drum is the invention of Mr. Houghtaling. A worm wheel fixed to the base of the drum (Fig. 2) engages with an endless screw with several threads upon whose shaft is mounted loosely one of the pulleys of a set furnished with the apparatus. The one chosen is that which has a circumference corresponding to a quarter or a fifth of the piston stroke, so that, during such stroke, the pulley shall make four or five revolutions under the action of the cord that connects it with one of the parts of the engine.

Three pulleys, of the respective diameters of 25, 50, 87 mm., suffice for the taking of diagrams upon engines whose stroke varies from 0·15 m. to 1·2 m.

With the pedestal of the endless screw there is connected a box containing a small spiral spring. This latter, which is tightened during the forward stroke, causes the pulley to revolve in an opposite direction and draws back the cord during the return stroke of the engine. There is no need of stopping the latter in order to unfasten the cords, since a coupling box mounted at the end of the shaft of the endless screw permits, through the maneuver of a button, of giving motion to the pulley or of suspending the same. Upon unscrewing the nut that is seen at the bottom of the apparatus (Fig. 1), it is possible to remove the entire transmitting mechanism and to substitute for it a guide pulley of the ordinary type.

The Houghtaling apparatus may be arranged in two ways, according as it is desired to operate with two hands or with one. It is to the first of these arrangements that Figs. 1 to 3 refer.

As may be seen, the idle pulley, 2, of the shaft of the endless screw, 6, engages with a pin, 4, which is connected with one of the extremities of the spiral spring, 3, whose other extremity is fixed to its box or barrel.

Upon the shaft, 6, is keyed a coupling box, 5, traversed by two pins, 8 and 9, which are connected with the ring, 7, that carries the milled edged button, 1, and which serve to guide it during the shiftings to which it is submitted upon its shaft in order to throw the mechanism of the drum into and out of gear. The motion of the latter is suspended by simply pulling back the ring until the stop of the pin, 8, abuts against the bottom of its recess in the coupling box, 5. On the contrary, in order to start it, the ring is pushed forward so as to cause the extremity of the pin to enter one of the notches with which the hub of the pulley, 2, is provided. This pulley, according to the direction of revolution of the coupling box, 5, does or does not participate in its motion. During the forward stroke of the

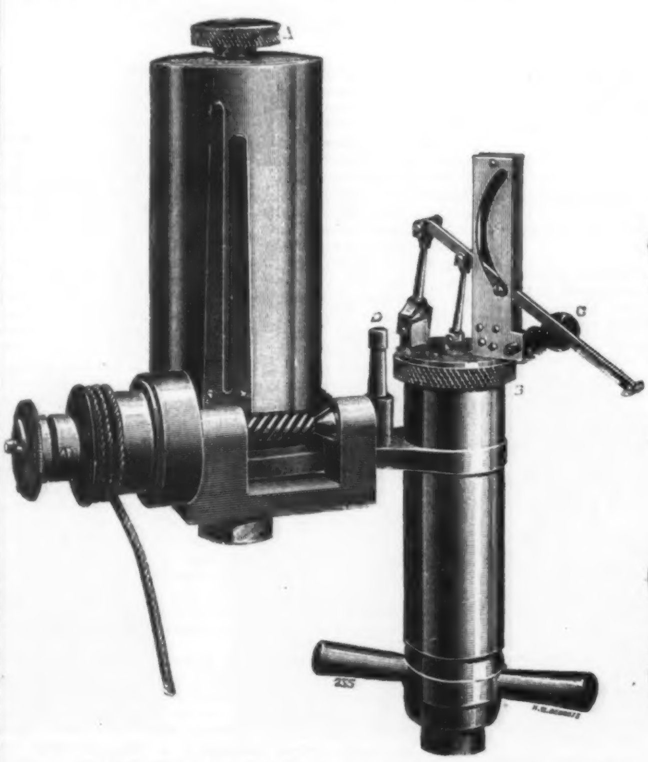


FIG. 1.—TABOR MODIFICATION OF WATT'S INDICATOR.

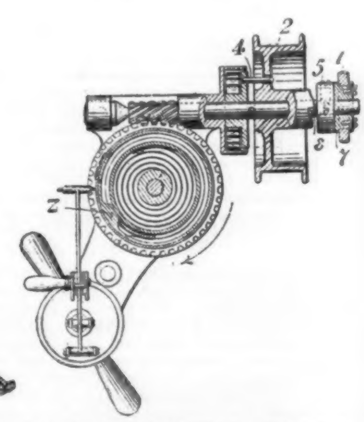


FIG. 2.—HORIZONTAL SECTION.

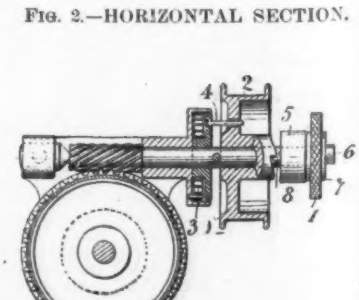


FIG. 3.—COUPLING GEAR.

engine, and consequently during that corresponding to the taking of the diagram, the pulley revolves and carries along the drum. In the back stroke the pin, 8, slides over the notches of the pulley hub, and the cord winds around the pulley under the action of the spring.

It is necessary to place the apparatus in such a direction that the cord shall run at right angles with the shaft, 6, and that, having unwound, it shall again make two or three turns upon the pulley, 2. The spring should therefore have a tension just sufficient to wind the cord around the pulley. An excess of power would strain it uselessly.

Before taking a diagram, it is well to give the drum an initial movement forward, in order that at the end of the back stroke the stop, Z, of its spiral spring may not come into contact with the tappet (Fig. 2). In this way, a shock prejudicial to the apparatus is avoided, and the spring preserves a constant initial tension. To this effect, the operator with one hand turns the milled head, A, which is mounted loosely at the top of the axis of the drum and is provided underneath it with a pin that carries along another fixed to the drum itself. Then, with the other hand, the operator presses upon the head, 1. The throwing into gear having been effected, he allows the drum to follow the impulsion that is communicated to it mechanically.

The drum may be stopped instantaneously at any moment and the paper be removed from it. It suffices to pull upon the button, 1, in order to throw the pulley out of gear and cause the unwinding of the paper in turning the head, A, of the top. During this maneuver the pulley, 2, continues to revolve independently of the drum.

In Figs. 2 to 3 may be seen some of the details of the arrangement that permits of operating with a single hand for giving the necessary advance to the drum and for throwing the mechanism into gear. Upon the external face of the ring, 7, is screwed the ratchet, r, and opposite, but upon the milled head, 1, loose in the ring, is fixed the click, c. A spring, s, situated behind the head, 1, tends constantly to disengage the click and consequently to maintain an independence between the ring and the milled head.

For operating, we begin by exerting a slight pressure with the finger upon the click, c, which engages with the ratchet, r. Then, while preventing the coupling box, 7, from advancing, we revolve the head, 1, so as to give the drum the requisite initial advance. It then only remains to throw the mechanism into gear by giving the coupling box, 7, a slight push. At the moment at which the pin, 8, engages with the pulley 2, the click, c, becomes disengaged by reason of the rotary motion given the ratchet, r, and of the inclination of the latter's teeth.—Revue Industrielle.

AN IMPROVED FIELD GLASS.

The accompanying illustrations represent a collapsible field and opera glass invented by Mr. Aitchinson, of Fleet Street, London. The spiral tubes are

Fig. 3.

telescopic, and when closed up they occupy a very small space and may be readily slipped into the pocket. The inventor has also provided a separate attachment for the use of officers or others who have use for such glasses in the field, by means of which the glasses may be attached for permanent use, leaving both hands free for making notes or other purposes. The glasses, being made of aluminum, are extremely light. By fitting them with a special nose piece and a head strap, they may be worn as easily as a pair of spectacles, leaving both hands free.

Fig. 1 shows the method of attaching the nose piece, which is effected by slipping the plate on the eye pieces at B B, and then pushing in the staple-shaped key, F, in Fig. 3. The operation does not take four seconds. The straps are placed round the head and the glasses are then worn as shown in the diagram, Fig. 2. It is quite easy, while keeping the glasses in place, to see under them for the purpose of writing or sketching. The arrangement seems likely to be very useful to war correspondents at rifle ranges, and, in fact, under all circumstances where it is necessary to make observations and take notes at the same time. We are indebted to the London Engineer for the cuts.

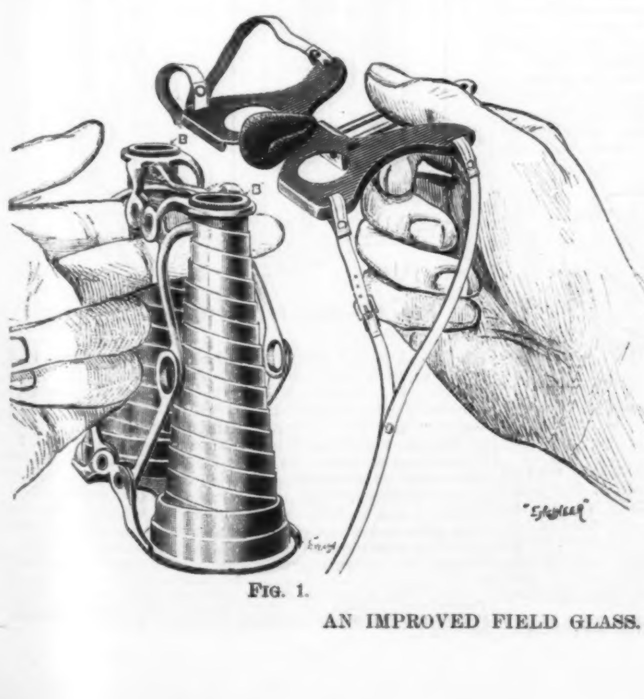


Fig. 1.

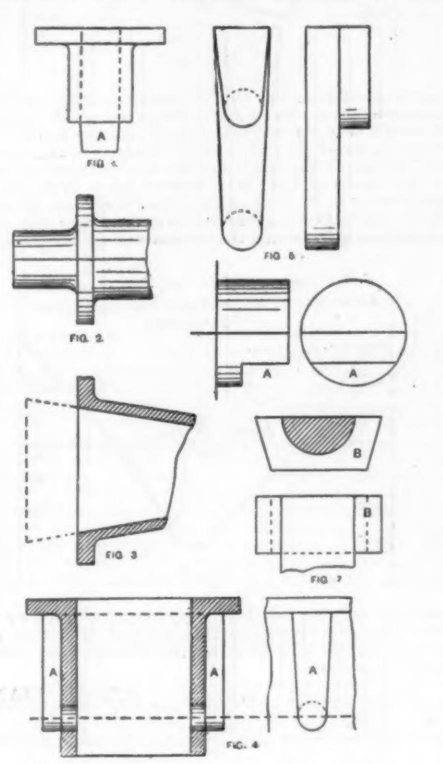
Fig. 2.

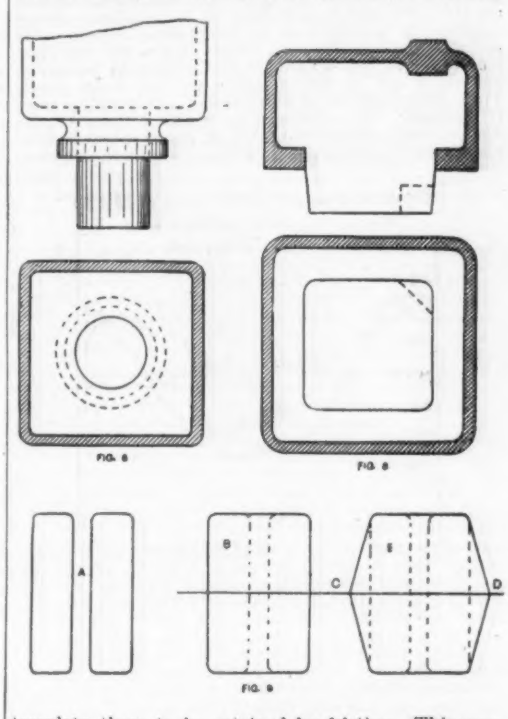
AN IMPROVED FIELD GLASS.

CORE PRINTS.

By Herbert Aughtie, in the Practical Engineer.

Whenever the internal parts of a casting have to be formed in the mould by means of sand cores, it is usually necessary to form seatings for the latter by





attaching core prints to the pattern. In Fig. 1 the lower part, A, is the core print on the pattern of a gland. It is circular in section and slightly tapering. When the pattern is withdrawn from the sand the depression it leaves serves to carry the circular core which forms the hole through the gland. If the depth of the pattern is not great, the core may be trusted to keep its position without a print at the top, but if the pouring of the metal is likely to disturb its position, another print is attached to the top of the pattern. Top prints differ materially from bottom prints, being very much shorter, and with a greater amount of taper. This is so because the top part of the mould has to be lowered upon it, and the shape described will render the core much less likely to be crushed or the mould broken than if it resembled the bottom print. If a core has considerable diameter and relatively small length—say, for instance, 12 in. by 12 in.—it is not only sufficient to have but one print, but that one may be of very small depth, say ½ in. or ¾ in., for it is clear that the core will be able to stand firmly on its own base, the chief function of the print being to define the position of the core. In some cases no prints at all are used, the cores being set by rule or gage strips. In the case of Fig. 1, the depth of the print is necessary to enable the core to maintain its position, as, even if a top print is used, it is not available until the mould is closed.

Fig. 2 shows one of the prints, A, of a flanged pipe, which is moulded horizontally. These are made parallel, and if they are slightly bell shaped (as B) where they join the pattern, an effect is produced similar to that of "finning" the joints of moulds. It simply insures that when the mould is closed there will be no pressure upon the weak edges of the mould, which would be likely to break them down. Sometimes (when by so doing work may be saved in making the core box) the print of a casting of tapering section may be made, as in the dotted lines of Fig. 3, to continue the taper of the hollow. Such a pattern would, of course, be drawn from the sand in a direction parallel to the plane of the flange.

If cores have to be inserted which do not lie in the plane of the joint, and cannot be inserted in the body of the mould, they may frequently be put in by the aid of a "drop" print. In Fig. 4 is shown a flanged box of rectangular section, in which circular holes, B, B, are required. The pattern is supposed to leave its own (main) core or "cod" in the green sand. Two flat circular cores, B, B, may be made, equal in thickness of metal, and pushed into place by a wooden template, there to be retained by friction. This way would require no prints at all, but a far better method is to attach prints shaped like A, A. Into the impressions left in the sand may be placed cores which not only form the holes, but also fill up the cavities in the mould external to the form of the casting; or small cylinders of sand may be laid in the bottom, and the rest of the space filled up with green sand; this is prevented from falling into the mould by holding a small flat piece of wood in the space left by the pattern. Should two or more holes be required to be made in this way, the prints may be adapted (as in Fig. 5), by putting them in tiers; but the more holes there are the more desirable it is to make a core box to fill up the entire space, as not only will one plain print then be sufficient, but the time of the moulder is saved, and greater accuracy is attained.

In Fig. 6 is shown a pattern of a rectangular chamber having circular openings. If drawn from the sand in a line perpendicular to the plane of the section, the core may be carried by circular print impressions, and adjusted to give an even thickness of metal in the rectangular part by means of gage strips. To save the time taken in doing this, a flat surface parallel to the joint of the mould may be cut on the bottom of one of the prints for part of its length, as A, Fig. 7, or (and this is a much better method if the print be not of large size) the necessary flat surface may be formed by attaching a supplementary piece to the print (B, Fig. 7).

In Fig. 8 is shown a case in which a pattern is moulded with the core vertical, in which, although the shape of the print (here square with rounded corners) automatically regulates the thickness of metal, it is necessary to place the core in one of four possible positions, for in the present instance the internal eccentric boss would not match its external counterpart if placed in either of the three other ones. This end is secured by cutting away one corner of the print, as shown in the dotted lines. The corresponding corner of the core box must, of course, have the part cut off fastened within it.

Although, generally speaking, the shape of the core represents the shape of the opening in the casting, yet there are some cases in which an advantage is secured by making them otherwise. Let Fig. 9 represent two openings made by separate cores, very near each other, in the face of a casting. If two prints are made, a very narrow and weak partition of sand, A, remains between the spaces left in the mould, and the integrity of which is not only threatened when the pattern is withdrawn, but again when the cores are placed. A much better plan is to fix one print (as B), in which case the two cores butt together, each being extended into the print space in order to fill it up.

For the same reason that the top prints of circular cores are considerably tapered (viz., to enable the mould to be closed without damage), the print, B, may with advantage be still further varied from the shape of the opening if the joint of the mould happens to come (as is likely) in the line, C D.

At E this is shown, and consists in tapering the print

away from the joint, forming four triangular extensions of the print space, which are filled up as before by making the core box to correspond. It is important that all prints should be plainly marked before the patterns are sent into the foundry by coloring them so that they contrast in appearance to the pattern itself, otherwise there is a danger than the moulder may treat them in some cases as bosses of metal. Although "checks" and other devices for adjustment, etc., are not always strictly necessary, yet the advantages of saving the moulder's time when a pattern has many castings made from it, and the lessening of his liability to error, will generally make it worth while to adopt them in the pattern shop.

[Continued from SUPPLEMENT, No. 1084, page 17331.]

ALTERNATE CURRENT TRANSFORMERS.*

By DR. J. A. FLEMING, F.R.S.

LECTURE I. (Continued.)

THIS leads to the conclusion that in testing a high tension alternator for efficiency, it is quite sufficient to load up the machine on water resistance to measure the current going out of the machine as ordinarily measured on an alternating current ammeter, to measure the difference of potentials at the terminals of the machine, as measured on an alternating current voltmeter, and to multiply the values of the two readings together, and thus obtain the true power in watts being given out by the machine on the water load. There is no question of difference of phase in this case. If, however, the alternator is working upon an inductive load, such as a number of transformers lightly loaded, then the current curve lags behind the electromotive force curve by a definite amount at the zero value. This is shown in curves Figs. 11, 12 and 13, giving respectively the electromotive force and current curves of a Mordey alternator and a Thomson-Houston alternator working on transformers lightly loaded. It will be seen that the difference of phase between the current and electromotive force curves is different at different parts of the curve; in the case of the Thomson-Houston alternator there is no difference of phase between the maximum values of the current and electromotive force, but a considerable difference between the zero values. In the diagram of the Thomson-Houston alternator the position of the field poles is shown by the square rectangles, which, therefore, indicate the manner in which the electromotive force curve is related to the field poles in the machine. It must not be supposed that the form of the current curve or of the electromotive force curve is a fixed attribute of the alternator; that is to say, we cannot speak of the electromotive force curve of an alternator as if it were something unchangeable and peculiar to that machine. It often largely depends upon the nature of the load.

Current and part of E.M.F. Curves of an A.20 Mordey Alternator on Night Load of about 72 Amperes.

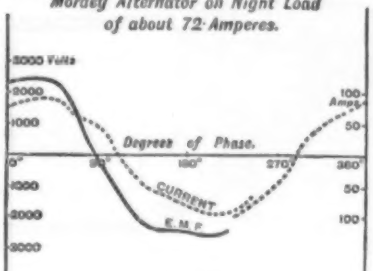


FIG. 11.

E.M.F. and Current Curves of an A 20 Mordey Alternator on Night Load of 70 Amperes.

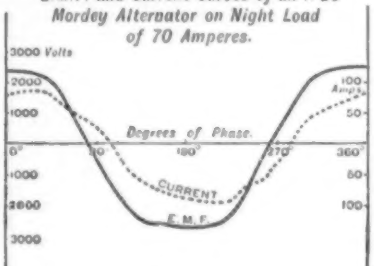


FIG. 12.

E.M.F. and Current Curve of a T H. Alternator on Night Load of 72 Amperes.

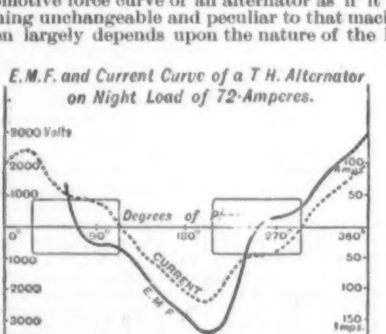


FIG. 13.

Thus, for instance, in Fig. 14 is shown the form of the electromotive force curve of a Thomson-Houston alternator when very lightly loaded, and in Fig. 15 is shown the electromotive force curve of the same machine when loaded on a non-inductive resistance to a fair proportion of its full load; while, on referring to Fig. 13, we see the form of the electromotive force curve of the same machine when working on an inductive load, and it will be noticed how very different in form are those three curves. Generally speaking, in a machine like the Mordey alternator with a very small armature reaction, there is very little change in the form of the electromotive force curve with the nature and amount of the load on the alternator, but in the

T.H. Transformer at No Load. Primary Current Curve. Primary E.M.F. Curve off T.H. Alternator at No Load.

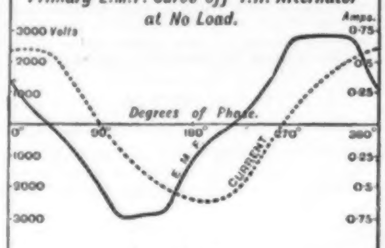


FIG. 14.

case of a machine like the Thomson-Houston or Westinghouse alternator with a large armature reaction there is a very considerable change in the form of the electromotive force curve which changes in the amount and nature of the load. In the above cases the forms of the electromotive force curves have been set out graphically in what are called wave diagrams, in which the horizontal ordinates represent time and the vertical ordinates represent the magnitude of the quantity,

E.M.F. and part of Current Curves of T.H. Alternator on single Water Resistance Load of 70 Amperes.

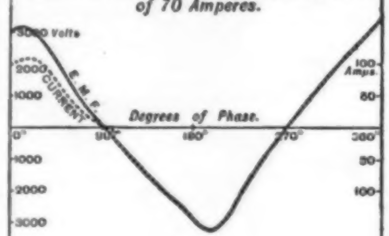


FIG. 15.

which is varying, whether electromotive force or current. For some purposes this method is not so convenient as that of setting out the curves in the form of polar diagrams.

The differences between these two methods—graphically delineated a periodic quantity—are shown in Figs. 16 and 17. In Fig. 16 part of the curve of the electromotive force of a Thomson-Houston alternator

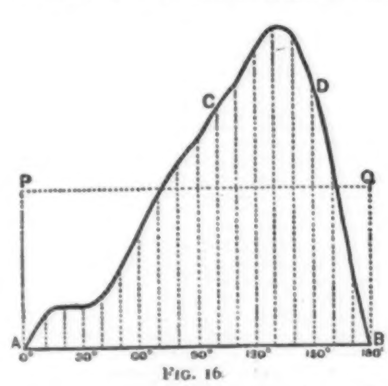


FIG. 16.

on an inductive load is shown. In Fig. 17 the same quantity is delineated in a polar curve. Instead of drawing vertical ordinates at equal distances to represent the instantaneous values of electromotive force, radii are drawn from a point, O, at equal angular intervals, the magnitudes of which are respectively proportional to the instantaneous values of the periodic quantity. A curve, B C D, is thus obtained, which is called a polar curve. It has this interesting property that if we find the area of the polar curve and describe a semicircle on a line, P Q, passing through the pole, O, the area of which is equal to the area included by the polar curve, B C D, it can easily be shown that the

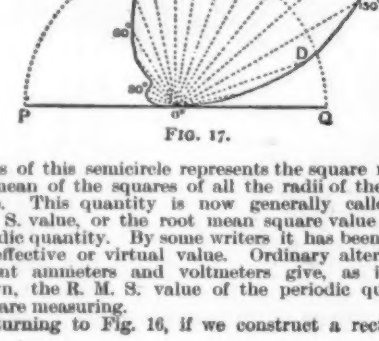


FIG. 17.

radius of this semicircle represents the square root of the mean of the squares of all the radii of the polar curve. This quantity is now generally called the R. M. S. value, or the root mean square value of the periodic quantity. By some writers it has been called the effective or virtual value. Ordinary alternating current ammeters and voltmeters give, as is well known, the R. M. S. value of the periodic quantity they are measuring.

Returning to Fig. 16, if we construct a rectangle, A P Q B, equal in area to the area included by the wave curve, A C D B, then it is easily seen that the height of this rectangle, namely, A P, represents the true mean value of the periodic quantity represented by the ordinates of the wave curve. In the case of any periodic quantity, such as a periodic electromotive force or current graphically delineated, it is found convenient to have a term to denote the ratio between the true mean value of the curve ordinate and the root mean square value, and this is called the form factor of the curve.* Having thus seen the manner in which we can experimentally determine the form of an electromotive force or current curve which represents the different instantaneous values of a periodic electromotive force or current, we can now proceed to discuss the manner in which these methods have been applied in the study of the alternate current transformer. Let us first suppose that the transformer to be studied is a constant potential transformer, having two windings, a primary and a secondary coil, both wound round an iron core forming a completely closed iron magnetic

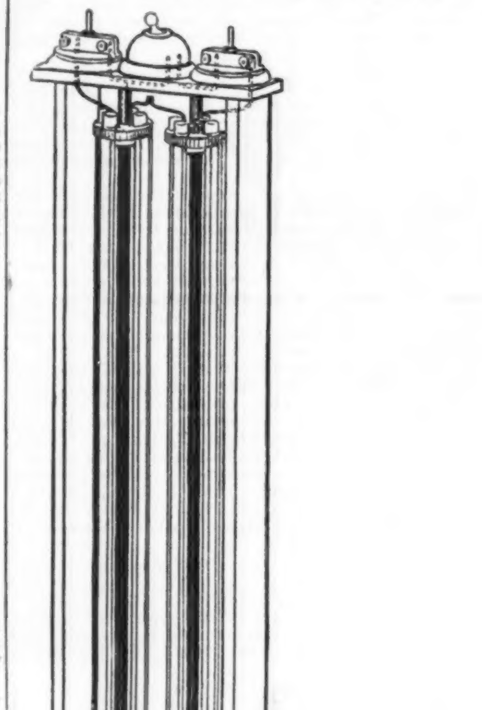


FIG. 18.—NON-INDUCTIVE RESISTANCES.

circuit. Let the primary coil be joined up through a non-inductive resistance, R^1, as shown in Fig. 2, with a circuit of constant potentials, and let the contact breaker above described, denoted by C, and the electrostatic voltmeter, V, be applied to determine the form of the current curve flowing into the primary coil, P, of the transformer. In order to delineate the form of the curve of primary potential difference, it is necessary to put across the primary terminals of the transformer a non-inductive resistance, R^2, which is divided in a definite ratio, so that by measuring a fraction, say $\frac{1}{10}$ of the whole difference of potentials between the terminals of the primary circuit of the transformer, we

* Lecture before the Society of Arts.—From the Journal of the Society.

* For further information on this point, see "The Alternate Current Transformer," Fleming, vol. i (new edition), p. 583, published by "The Electrician" Printing and Publishing Company, 7 Salisbury Court, Fleet Street, E. C.

can determine the total potential difference. After much experimenting, I succeeded in devising a form of resistance which is now before you and which is very convenient for this purpose. It is called a resistance cage. It consists, as you see, of a series of brass rods held in a wooden frame, each rod carrying a pair of porcelain heads with porcelain pins on them (see Fig. 18), and these porcelain heads are kept pressed apart by a spring. Over the pins on these porcelain heads is wound, in zigzag fashion, a platinoid wire, so as to form a perfectly ventilated non-inductive resistance. Each of these resistances is adapted for withstanding 100 volts pressure and carrying one-half or one ampere, and a series of twenty of these resistances can be put

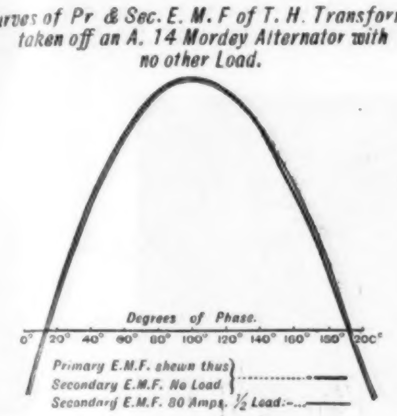


FIG. 19.

across the primary terminals of a transformer and will withstand the pressure of 100 volts for as long as necessary. By measuring the fall of potential and delineating the periodic value of the difference of potential between the terminals of one cage, which forms one of a series of twenty, we can delineate the whole difference of potential between the terminals of a transformer. In this way we can take curves of primary current and primary electromotive force on the high tension side of a transformer. In the next place we can perform the same operation on the secondary side of the transformer and obtain the secondary terminal potential difference curve, and also, if the transformer is sending a secondary current, the secondary current

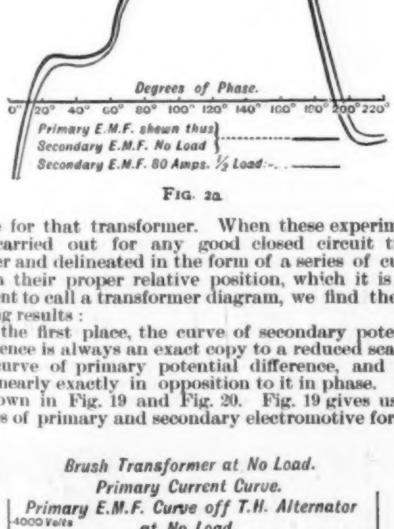


FIG. 20.

curve for that transformer. When these experiments are carried out for any good closed circuit transformer and delineated in the form of a series of curves set in their proper relative position, which it is convenient to call a transformer diagram, we find the following results:

In the first place, the curve of secondary potential difference is always an exact copy to a reduced scale of the curve of primary potential difference, and it is very nearly exactly in opposition to it in phase. This is shown in Fig. 19 and Fig. 20. Fig. 19 gives us the curves of primary and secondary electromotive force of

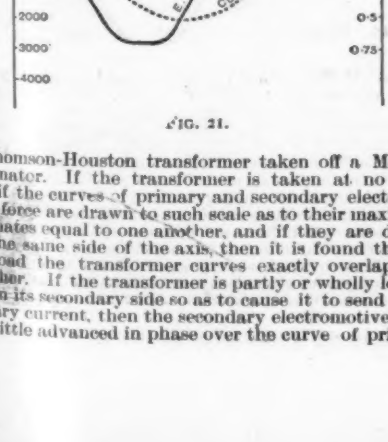


FIG. 21.

a Thomson-Houston transformer taken off a Mordey alternator. If the transformer is taken at no load, and if the curves of primary and secondary electromotive force are drawn to such scale as to their maximum ordinates equal to one another, and if they are drawn on the same side of the axis, then it is found that at no load the transformer curves exactly overlap one another. If the transformer is partly or wholly loaded up on its secondary side so as to cause it to send a secondary current, then the secondary electromotive force is a little advanced in phase over the curve of primary electromotive force, as shown in Fig. 18. Fig. 20 shows the same thing for the same transformer taken off a Thomson-Houston alternator. Hence we see that the closed circuit transformer acts like an electrical pantograph; it copies electrical potential difference, and the curve of secondary potential difference is always a nearly exact copy of the curve of primary potential difference, but to a reduced scale depending on what is called the transformation ratio of the transformer. On delineating the curve of primary current of the transformer when the transformer is taken at no load, as shown in Fig. 21, we see that the curve of primary current, when the secondary circuit is open, differs in phase from the curve of primary potential difference. It lags behind it, and the same thing is shown by reference to Fig. 14, where the curve of primary electromotive force for another transformer taken off the same alternator is given. It will be seen that even if the

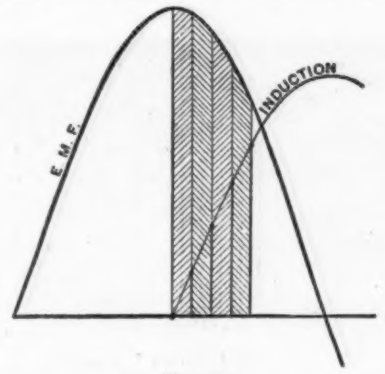


FIG. 22.

same alternator is employed for the test, the curve of primary current at no load is not the same in form in the case of all transformers. The form of this primary current curve is governed by the nature of the iron employed in the core. We then notice that even in cases where the primary electromotive force curve is more or less approximately a sine curve or simple periodic curve, the curve of primary current is always more irregular. Having in this manner delineated the curves of primary current, primary electromotive force and secondary current, we have then to determine the manner in which the induction in the core is varying with relation to these other varying quantities. We can draw out a curve of induction from the curve of a secondary electromotive force in the following manner:

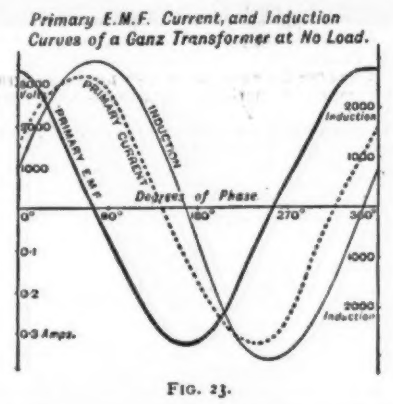


FIG. 23.

Since the secondary electromotive force of the transformer at any instant is measured by the rate at which the magnetic induction linked with the secondary circuit is varying, we can construct the induction curve in the following way, as shown in Fig. 22. The curve marked E. M. F. represents a transformer secondary electromotive force curve. The whole area of the curve is divided into two equal parts by a vertical line. Starting from this vertical line, half of the curve, say the right hand half, is divided up into narrow strips of equal area, which are represented by the cross hatched slips. The areas of these very narrow slips are then

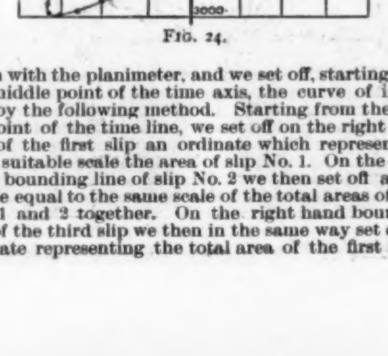


FIG. 24.

taken with the planimeter, and we set off, starting from the middle point of the time axis, the curve of induction by the following method. Starting from the middle point of the time line, we set off on the right hand side of the first slip an ordinate which represents to some suitable scale the area of slip No. 1. On the right hand bounding line of slip No. 2 we then set off an ordinate equal to the same scale of the total areas of slips Nos. 1 and 2 together. On the right hand bounding line of the third slip we then in the same way set off an ordinate representing the total area of the first three slips, and so on. In that way we obtain points on a curve which represents what is called the time integral of the electromotive force curve, and this is, therefore, the proper representation for the induction curve. In order to determine the scale to which this induction curve is drawn, we must know what is the value of the maximum ordinate of the induction curve. This can be done in the following manner. If B represents the induction in the core, S the cross section of the core, N_2 the number of turns of the secondary circuit, n the frequency of the alternating current, and f the form factor of the secondary circuit curve; then it can be shown that the root mean square value of the secondary electromotive force is equal to 4 f. n. N_2 S B; and hence, since the root mean square value of the secondary electromotive force is immediately known from the delineated curve, and also its form factor, we can easily calculate the value of B, that is, of the induction.* That is to say, in this manner not only can we thus delineate the curves of current electromotive force, but also the induction, and represent them graphically on the same diagram. In Fig. 23 are shown the curves of primary electromotive force, primary current, and induction for a Ganz transformer taken at no load. The curve of induction can be determined in the above described manner, not only from the curve of secondary electromotive force, but also from the curve of primary electromotive force. If this is done, it is found that two curves of induction so obtained do not exactly coincide. The reason for this is the magnetic leakage of the transformer. This last term is best defined by saying that when the transformer is at work, and sending a secondary current, the whole of the magnetic induction which is linked with the primary circuit is not linked with the secondary circuit. There is, as it were, an escape of induction from the secondary circuit which is called the magnetic leakage. In discussing in a later lecture the testing of a transformer, we shall consider how this quantity can be measured. Having delineated the whole of these curves for a transformer, we are then in a position to draw a hysteresis diagram for the transformer. To do this, we have to set off in the form of a cyclic curve the variation of induction with magnetizing force. It can easily be shown that if we construct a closed curve, by setting off on a horizontal axis the different instantaneous values of the primary ampere turns of a transformer on open secondary circuit taken at equal time intervals during the phase, and if corresponding with these we set off the vertical ordinates representing the total induction in webers in the core of the transformer corresponding to these different values of the ampere turns, then the total area of that curve integrated in turns of a unit of area—one side of which represents a weber, and the other side of which represents an ampere turn to the selected scale—will give us the value in joules of the energy wasted in the core of the transformer in one complete magnetic cycle, and in this manner we can determine from the transformer diagram the power wasted in watts in the core when the transformer is on open secondary circuit. This power is spoken of as the iron core loss in the transformer, and it can be determined directly from the transformer diagrams. In a later lecture we shall see how it can be more conveniently determined by one single direct measurement with the wattmeter. The diagram in Fig. 24 shows the hysteresis diagram thus determined for a Ganz transformer.

We have now briefly reviewed the chief actions going on in the transformer. Let us sum them up. If we apply to the terminals of a transformer a periodic electromotive force varying according to any law, we find that we have a periodic current set up in the primary circuit which lags behind the primary electromotive force when the transformer is an open secondary circuit, but which gradually comes into step with it, in proportion as the transformer is loaded up. In good closed circuit transformers a very small amount of loading up—even as much as one-fiftieth of full load—will suffice to bring the primary current curve into step with the primary electromotive force curve. Secondly, we have a periodic magnetic induction in the core, which differs in phase, both from the primary current and the primary electromotive force; and it is found that this magnetic induction curve is always a more regular curve than the curve of primary electromotive force. When the curve of primary electromotive force is approximately a simple periodic curve, then the curve of induction is more nearly a simple sine curve. Thirdly, we have a curve of secondary electromotive which is similar in form to, and exactly opposite in phase to, the curve of primary electromotive force when the transformer is on open secondary circuit, or when it is sending a small secondary current into a non-inductive resistance. If the secondary circuit of the transformer is practically non-inductive, as it is when the transformer is working upon a load of incandescent lamps, then the curve of secondary current is always in step with the curve of secondary electromotive force, and can be deduced from it. Lastly, we have a curve deduced from the curve of induction and primary current of no load which give us the hysteresis curve of the transformer. The curve of primary current of no load is generally spoken of as the magnetizing current, and the total power taken up in the iron core in watts is spoken of as the iron loss of the transformer.

ELECTROLYTIC COPPER AND SILVER REFINING.†

FEW electricians are aware of the vast proportions which the industry of the electro deposition of metals has assumed within the past few years. In 1894, 57,500 tons of copper, or almost one-third of the entire copper output of the United States, was electrically refined; since then there has been a large increase, and at the present time not far from one-half of all the copper produced in this country is refined in the electrolytic bath.

One of the latest electrolytic refining plants erected in this country is that of the Guggenheim Smelting Company, at Perth Amboy, N. J., which has an annual capacity for about 10,000 tons of copper and 80,000 oz. of silver, and is equipped for the most modern processes of refining. The copper here refined carries a large percentage of gold and silver, and the silver parting plant

* See "The Alternate Current Transformer," vol. 1 (new edition), page 358.

† For the article and engravings we are indebted to the American Electrician.

also handles the precious metals separated from a rich lead bullion that undergoes a final heat metallurgical process at these works. The refinery is in operation 365 days in the year.

The copper is received at the works in bars, having already undergone the process of raw smelting from the ore and concentration from the resulting matte. At the works the metal is again heated in reverberatory furnaces and then cast into anodes for the electrolytic bath. Before commencing a description of the final or electrolytic process, the electrical generating plant will be considered.

Electrical Generating Plant.—The boiler plant consists of five Babcock & Wilcox boilers rated at 125 horse power each, and generating steam at 150 lb. pressure. The dynamo generating plant consists of two systems—one supplying current for the commercial copper depositing baths and another for the electrolytic manufacture of cathode plates, whose object will be explained later.

The commercial plant consists of two Porter-Allen triple expansion condensing engines, running at 250 r. p. m. and driving two General Electric generators, the commutator end of one of which is shown in Fig. 2. The generators are of the eight-pole multipolar type, each of a capacity of 180 kw., and delivering 1,500 amperes at 120 volts; they are shunt wound with smooth core armatures of the ring type.

With generators for this service, the matter of brushes is an important one. In the present instance good satisfaction is being given by woven wire brushes, of which there are three to each brush holder, or twenty-four in all, the cross section of each brush being $\frac{7}{16}$ in. × $1\frac{1}{2}$ in. The switchboard of the commercial plant is shown in Fig. 2.

The cathode system is supplied by a General Electric generator, shown in motion in Fig. 3, specially designed for the plant. It is a four pole machine with a capacity of 12 kw., and delivers 1,000 amperes at 12 volts; the field is separately excited from a 110 volt power circuit. The commutator is twenty-four inches in length, fourteen inches in diameter and contains forty segments, each $1\frac{1}{16}$ in. wide. The brushes, sixty-four in number, are of carbon, containing a copper wire core; the cross section of the brushes is $1\frac{1}{4}$ in. square. The cathode generator is driven by a standard 25 horse power Westinghouse engine.

In addition to the electrolytic dynamos there are two four pole 40 kw. power generators and one 40 kw., 110 volt incandescent lighting generator. A considerable number of electric motors are employed for various purposes, their power ranging from 50 to $7\frac{1}{2}$ horse power. Two Otis freight elevators, a Shaw crane, and desilverizing kettle stirrers are operated by electric power.

The Cathode Baths.—In the system used at the Guggenheim refinery the copper is deposited on special cathode plates, which plates are prepared in a system of tanks separate from the commercial tanks. Rolled copper sheets $\frac{1}{16}$ in. thick receive the cathode deposit, which is permitted to become $\frac{1}{8}$ in. thick, both sides of the rolled copper being thus plated. Fig. 4 shows the rolled plates prepared for the bath. Wood strips form a frame about three sides of the plates; after the two surfaces are oiled and covered with graphite in order to prevent the cathode deposit from sticking, the plates are placed in tanks between commercial anodes, and after the necessary thickness of copper is deposited the shells are stripped from the plates and are ready for use as cathodes in the commercial tanks. There are 30 cathode tanks, each 8 ft. 6 in. long, 3 ft. deep and 2 ft. 6 in. wide. The cross section of the conductors supplying current to the tanks is $1\frac{1}{4}$ in. square.

The Commercial Baths.—Fig. 1 gives a general view of the tanks for the commercial deposition of copper, and a single tank is shown in Fig. 5. As will be seen, the tanks are arranged in terraces, the object of which is to facilitate circulation of the electrolyte. There is a difference of level of about two inches between each row of tanks, and an overflow pipe of the necessary diameter keeps up a sufficient circulation to maintain the electrolyte in proper condition—there being a constant supply of new fluid to replace that drawn off. The tanks, which number 360 in all, are of 2 in. pitch pine coated with "P. & B." paint, each being 9 ft. 10 in. long, 3 ft. deep and 2 ft. 6 in. wide. The electrolyte, as prepared for the bath, has in solution, by weight, 16 per cent. of bluestone, and 5 per cent. of free sulphuric acid. Samples from the tanks are frequently tested in order to insure reliability of result.

Each tank contains twenty-two anodes and twenty-three cathodes. The anodes for electro-deposition are cast in the shape shown in Fig. 6. They are 2 ft. 6 in. long, 2 ft. wide, 3 ft. 2 in. across the lugs, and $1\frac{1}{4}$ in. thick.

All of the 360 tanks are in series, and the plates of each tank are in multiple. On the outer side of each tank is a copper bar $1\frac{3}{4}$ in. square in cross section, and on the inner a wooden bar, which together form the supports for the anodes and cathodes; the two outer bars of each pair of tanks are the + and — conductors. The tops of the cathodes are bent as in Fig. 4, and hang from copper cross bars, while the anodes are supported by their lugs (Fig. 6).

The tanks are arranged in pairs, as shown in Fig. 7. M, M, M, M, are the ends of tanks, the supporting and conducting bars above referred to being represented by the heavy horizontal lines. The heavy vertical lines represent the anodes, and the lighter vertical lines the cathodes. The small circles under one end of each cathode and anode is a square porcelain insulating block, the object of which will be apparent from the next paragraph.

Referring to Fig. 7, current enters the lower tank to the left through its twenty-two anodes in multiple, of which one, A, is shown; the cathodes, it will be seen, are insulated from the positive conductor. The current then proceeds through the bath to the adjacent cathodes, B, B, and then, by means of the connectors, C, passes to the anodes of the second bath; then continuing through this bath, it enters the cathodes, D, passes to the extreme conductor, and enters the next pair of tanks, in which its course is the same as that just described.

It will thus be seen that the tanks of each pair are in series the same as the adjacent pairs of tanks. In the actual tanks, the connectors, C, are plates of copper 6 in. long, $2\frac{1}{2}$ in. wide and $\frac{1}{8}$ in. thick, supported on the two wood bars, L and L′, the end of a cathode and anode bar, respectively, resting on each plate.

The anode and cathode plates are separated by about $1\frac{1}{4}$ in. The current density is about 10 amperes per square foot (counting both sides of the anode plate), and it requires about twenty-four days of twenty-four hours to electrolytically transfer the copper of the anode to the cathode plate, the weight of the former

Fig. 1.—COPPER DEPOSITING TANKS.

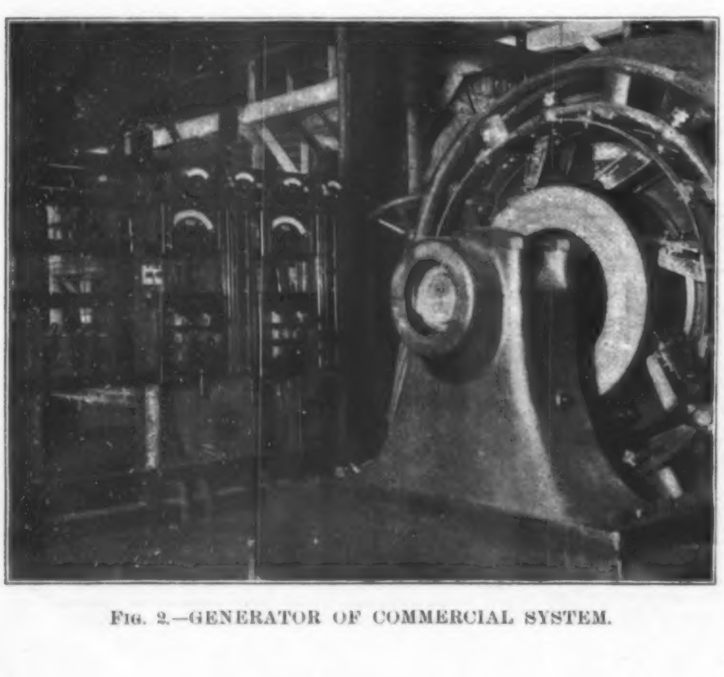


Fig. 2.—GENERATOR OF COMMERCIAL SYSTEM.

Fig. 3.—GENERATOR OF CATHODE SYSTEM.

being about 275 lb. The density of the current varies with the richness of the anode in precious metals; if a large quantity is present, a high density would carry part of the silver to the copper. In very pure copper a density as high as ten and even twenty amperes may be carried. The voltage, of course, depends only upon the ohmic resistance of the electrolyte, conductors and plates. With 356 tanks (four tanks are always out of circuit, having "slime" removed and being otherwise

FIG. 4.—CATHODE FORMER.

cleaned), the voltmeter at the switchboard registers from 117 to 120 volts with 1,500 amperes.

At Perth Amboy the copper refined is usually rich in precious metals, carrying at times 600 oz. of silver and 4 oz. of gold to the ton of copper. If the current is kept at the proper density, all of these metals, together with impurities like bismuth and antimony, are deposited in the bottom of the tanks in the form of a black slime,

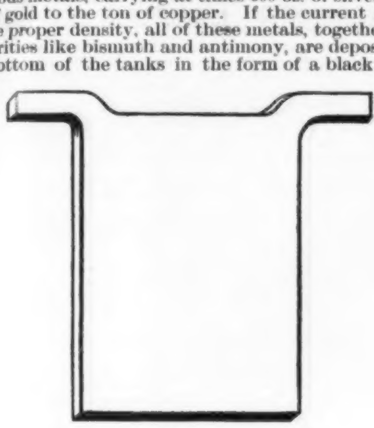


FIG. 6.—ANODE CASTING.

which name it goes by in the refinery. This slime is carefully gathered and passed through chemical and heat-reducing processes, which remove most impurities and concentrate the silver and gold; the latter is then ready for what is known as the electrolytic "parting" process. At the Perth Amboy works, lead carrying silver and gold is also refined, and the precious metals from the lead and the copper are united in one of the final processes of concentration preparatory to electrolytic "parting."

Silver Parting Plant.—The silver refining process used

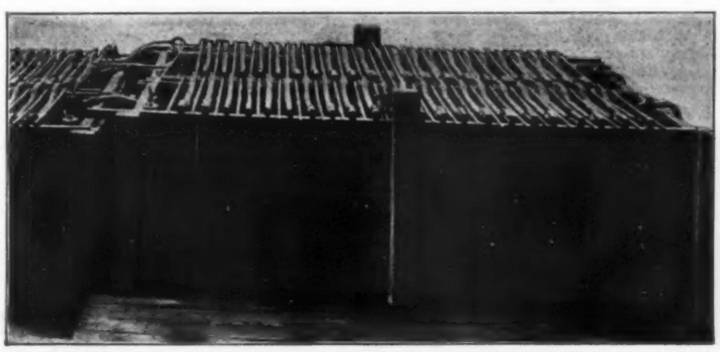


FIG. 5.—TANK OF COMMERCIAL SYSTEM.

FIG. 8.—SILVER PARTING TANK.

at Perth Amboy is that of Dr. B. Moebius, and is very interesting in its various details. The latest form of depositing tank is shown in Fig. 8, to which the description that follows will apply.

The peculiarity of the Moebius process consists in the employment of a belt for the cathode, which belt is alway kept in motion, and from whose surface the silver deposited from the anodes is continuously removed by scrapers located at one end of the tank. The belt, which is clearly shown in Fig. 8, is made of a sheet of pure rolled silver, 15 in. wide and 31 ft. long and weighing about 40 lb. Its upper portion passes about ½ in. beneath the lower surface of the anodes; the belt is given a motion of about 3 ft. per minute.

There are forty-eight Moebius tanks in the silver parting plant, grouped in eight sets of six tanks each. The tanks, which are made of 2 in. pitch pine coated with acid proof cement, are 14 ft. 3 in. long, 16 in. wide and 7 in. high, and are arranged in tiers of three.

In each of the latest type of tank there are twenty-four wood frames one inch deep, each of which contains an anode; over the bottom of the frames a muslin diaphragm is stretched, and the anode rests on four hickory cross rods about ½ in. above this: the cathode belt passes about ½ in. below the diaphragm. The anodes are 12 in. long, 3 in. wide and ½ in. deep, containing usually 100 oz. of silver and from 0·3 to 0·8 oz. of gold. The anode contact levers shown in the illustration are tipped with platinum; the cathode contacts are shown to the right of the cut, and consist of silver brushes bearing on the cathode belt. To the left of the tank is a revolving scraper or brush which, as the surface of the belt passes over it, removes the deposited silver and permits it to fall into the hopper shown in the illustration.

The electrolyte consists of nitric acid (38 Baumé) having dissolved in it granulated silver; some nitrate of soda and nitrate of copper are also added when starting up with a new solution.

A General Electric generator supplies 200 amperes of current. The voltage depends upon the strength of the nitrate solution and the length of time the anodes have been in circuit, but averages about ninety volts. All of the forty-eight tanks are in series, and the anodes of

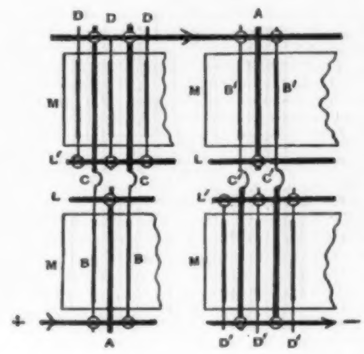


FIG. 7.—TANK CONNECTIONS.

each tank are in parallel. The capacity of each tank is 600 to 700 oz. of silver per twenty-four hours.

The residue from the anodes is principally deposited on the muslin diaphragms, and consists of gold, bismuth, lead and antimony. The former metal is finally recovered from the residue by chemical means.

The receipts of entrance money at the Berlin Exhibition were, for tickets for the Exhibition, for railways and for boats: May, 510,000 marks; June, 558,000; July, 630,000; August, 633,000. Season tickets: 90,000 marks, 12,000, 1,000, 4,000. Totals: May, 600,000 marks; June, 570,000; July, 631,000; August, 637,000; which is, for the four months since the opening of the Exhibition, 2,438,000 marks, i. e., taking the average entrance price of 0·50, exactly 5,000,000 paying visitors.

THE HOSPITAL SYSTEM ON RAILWAYS.

IN the days of the old woodburner, when twenty-five miles an hour was all that was expected of a fast train, and twelve to fifteen was the schedule of an ordinary freight train, when only two or three trains passed over the road in twenty-four hours, the railway surgeon was an unknown quantity.

As time progressed and the iron horse began to put in an appearance in the great western country, pulling great trains of merchandise from the East and returning ladened with grain and cattle, it became necessary to increase the number and speed of those trains. With such demands came the employment of more men, and in 1863, when the construction of the Central Pacific Railway was commenced, the country along the line of the road being then but sparsely settled, the care of the sick and injured employes, who had been recruited mainly from the East, and were away from their families or were mainly single, became a question of serious consideration. Then it was that N. A. Towne, now vice-president and general manager of that road, stepped to the front and established the first railway hospital department the world had ever known. He established the Central Pacific Hospital, at Sacramento, in November, 1868, at a cost of $64,000. In 1888 the daily average number of beds occupied was sixty-three, at a cost of $1.30 for each bed, being a total cost per diem of $76.37. This was maintained by deducting 50 cents monthly from the pay of every employe, except steamboat hands and Chinamen. The multiplication of branch lines, the increase of traffic, and increased speed of trains have also multiplied the source of injury. The company has only one hospital of its own, but has arrangements with hospitals in San Francisco, Oakland, Los Angeles, Tucson, and Portland, Or., paying so much per week for the care of its sick and injured employes.

The success attained by the management of the Central Pacific in its compulsory assessment hospital system was not without its good effects east of its own lines. Two railway surgeons, Dr. J. W. Jackson and Dr. W. B. Outten, were not idle during this time, and in 1879 Dr. Jackson gained the consent of the Missouri Pacific officials to establish what has since proved to be the greatest railway hospital system in the world. In 1881 Dr. Outten established the same, or nearly the same, system on the St. Louis, Iron Mountain and Southern Railway and the eastern end of the Wabash; Dr. Jackson completing the system on the western end. The hospital system on the Wabash differs somewhat from that on the Central Pacific, inasmuch as the monthly assessments are voluntary and are participated in by all the employes, from the general manager down.

The Wabash has three hospitals, located at Springfield, Ill., Peru, Ind., and Moberly, Mo., under the charge of a salaried surgeon.

In 1885 Dr. Outten was selected as chief surgeon of the extended Gould system, M. K. and T., T and P., and I. and G. N. Railways. In 1886 he established the same system on these lines, and established hospitals at Palestine, Fort Worth, Carondelet, St. Louis, Sedalia, Kansas City, Independence, Springfield, and Danville. Some estimate of his work may be gleaned from the fact that the Missouri Pacific alone has over 250 surgeons in its employ. This expense is all borne by the monthly assessments, which in no case exceed fifty cents per capita. Dr. Outten has two great hobbies—the one his finely equipped hospital and the other the Railway Surgeon, the official organ of the National Association of Railway Surgeons, of which he is the able editor. This journal is devoted exclusively to railway surgery, and is issued every two weeks.

Other lines soon followed the pioneers in this system, notable among these being the Union Pacific, with its thousands of miles of road, the Denver and Rio Grande, the Cotton Belt, and many shorter lines. The Denver and Rio Grande hospital at Salida is a very fine structure, and was paid for out of the surplus of the monthly assessments. It cost in the neighborhood of $40,000 when new, and has received many improvements since. Hospital arrangements have also been made with St. Mary's, at Pueblo; St. Luke's, at Denver; and Mercy, at Durango. In addition to the usual hospital arrangements, this system has nearly 200 equipped medicine chests, which are in service on the four divisions. Stretchers are located at some thirty different points for the easy and comfortable transportation of sick or injured employes.

Having established these hospitals, the question of transporting the sick and injured to them with the least danger and most comfort next attracted the attention of those in charge, but it remained for Dr. Frank H. Caldwell, the chief surgeon of the Plant System, to solve this in a practical manner, and he now has in operation on the Savannah, Florida and Western, and Plant System, his car, which is a veritable hospital on wheels, and is made from an ordinary baggage or express car. Employes, whether sick or injured, can readily be moved to the nearest hospital with the least possible danger. A wide door is provided at the side for the admission of patients. The car is divided into a bedroom, sitting room and operating room. The beds are portable, and can be changed to suit the necessities of the case, or can be stowed away out of the road. The bedsteads are all made of iron, and are so constructed as to be readily folded when not in use, giving additional room in the ward department of the car. A lavatory and water tank are also provided. The operating room contains all the equipments usually found in a hospital.

From the appointment of the first railway surgeon on the Lehigh Valley, in 1860, up to the present time, this branch of the medical profession has had a wonderful growth. Medical colleges, recognizing the importance of the study in this particular line, have established chairs of emergency surgery, and appointed professors to them whose personal experience has been large. In the navy of the United States there are: 15 medical directors, 15 medical inspectors, 50 surgeons, 90 passed assistant surgeons, making a total of 170 medical officers. In the United States army there are: 1 surgeon-general, 1 assistant surgeon-general, 1 chief medical purveyor, 2 assistant medical purveyors, 62 surgeons, 111 assistant surgeons, making a total of 178 surgeons. It will be observed by these figures that there are only 348 surgeons in the army and navy of the United States to-day, while the railways employ some 70 chief surgeons and over 5,000 assistant sur-

geons. This of itself is evidence of the importance of this particular branch of the chirurgical art.

Nine years ago Dr. A. W. Ridenour, of Massillon, Ohio, conceived the idea that there should be a "National Association of Railway Surgeons," and to him is due the credit of projecting an association that in nine years became so large that the transporting of its members to the annual meetings became a serious question to the railway lines called upon to furnish the transportation. I am informed by Dr. Eugene R. Lewis, the efficient treasurer, that the membership exceeds 1,800. The sessions are held annually, at which times the foremost men in its ranks are called upon to read and discuss important subjects appertaining to their profession. Three years ago, during the session being held at Galveston, Texas, there came into existence a rival organization, which culminated in the first session being held in Chicago during November, 1894. The new organization, "The American Academy of Railway Surgeons," has for its object the elevation of the scientific work, and has as its sponsors such men as Dr. J. W. Galbraith, chief surgeon Union Pacific; Dr. C. K. Cole, chief surgeon Montana Central; Dr. John E. Owens, chief surgeon Illinois Central, and as every one will remember, medical director of the World's Columbian Exposition; and Dr. R. Harvey Reed, of Columbus, Ohio, who has probably written more about railway surgery and railway sanitation and is better known than any railway surgeon in America.

The Medico-Legal Society of New York City, composed of learned men from all over the world, has recently added a section of railway surgery, and at the Medico-Legal Congress, held near New York, in September, 1895, it was represented by some of its best men.

I cannot close this article without calling the reader's attention to a very peculiar geographical condition in connection with the hospital system on railways. The first hospital was established on the Pacific coast when railroads were few and far apart. It was a success, and was almost immediately adopted by other Western lines; and to-day no Western line and few Southern lines but what are at least under the guidance of a chief surgeon and a large corps of able assistants; but "right about face," and what do you find? Scarcely a line east of Cincinnati, Ohio, that has either a hospital system or a chief surgeon in charge of its lines.—Columbus Medical Journal.

[Continued from SUPPLEMENT, No. 1084, page 17329.]

APPARATUS USED FOR THE MANUFACTURE OF ACETYLENE.

IV.

THE Dickerson & Suckert Apparatus (Fig. 25).—The object of this apparatus is to render the disengagement of the gas regular and continuous and to liquefy it. In order to assure such liquefaction, the acetylene must first be freed from air, from condensable gas and from the water carried along. The following are the arrangements adopted to this effect.

The carbide is introduced into one of the forged iron generators, AA', which are provided with charging orifices, 11', and clearance orifices, 22', and which are placed in the tanks, BB', in which circulates a continuous current of cold water.

The water used for the reaction reaches the carbide in the generator through the discharge, 33. It is led through the gradually opened cocks, 18 and 18'. The acetylene mixed with aqueous vapor is disengaged through the tube, 3, and enters the worm, C, which is cooled by a current of cold water contained in the tank, D. The water of condensation of the vapor flows through the tube, 4', into the water reservoir, E, and the gas that separates therefrom passes through the tubes, 4 and 5, into the drier, F, in the interior of which there are shelves, 6, of wide surface, covered with calcium carbide. From the drier the gas enters the condenser, G, wherein it liquefies. It is collected in the receiver, I, which is surrounded by the refrigeratory, K, and is led thence through the pipe, 29, to the cylinder, L.

A beginning is made by filling the generator, A or

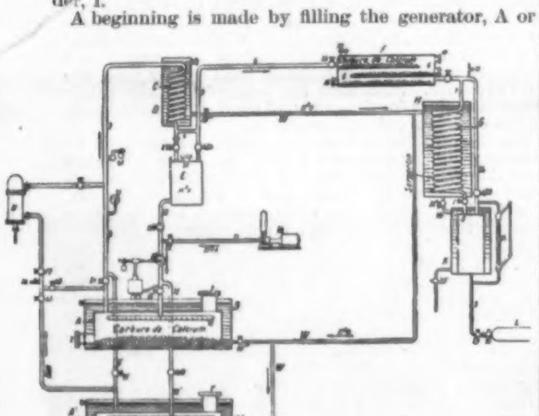


FIG. 25.—DICKERSON & SUCKERT APPARATUS.

A', and the drier, F, with carbide. After the charging orifices have been tightly closed, cold water is made to circulate in the refrigeratories by opening the cocks, 20[1], 20[2], 20[3], 20[4] and 30[4] of the pipes, W. The purge cocks, 15 and 16, the escape cock, 14, the cocks of the auxiliary conduit, 42 and 43, and the delivery cocks, 18 and 18', are first closed. All the other cocks are opened, and the cylinder, L, is removed.

The water used for the reaction is compressed by means of the pump, M, and is sent through the pipes, 11 and 12, and the cock, 19, to the reservoir, E. For a charge of 100 pounds of carbide in the generator, A, it requires 560 pounds of water in the receiver, E. The cock, 18, is then gradually opened, and the water is distributed over the carbide through the discharge, 33. The acetylene disengaged traverses the entire apparatus and expels the air through the pipe, 9, fixed to the bottom of the receiver, I. When the expulsion of the air is complete, the cock, 29, of the pipe, I, is closed, and the opening of the cock, 18, is so regulated that the pressure of the gas given by the continuous flow of the water shall be sufficient to produce the liquefaction. The cock, 40, serves to render the discharge of the water regular and to effect a uniform pressure. The gas that has escaped liquefaction in the receiver, I, returns through the pipe, 34, to the condenser, G.

The beginning of the liquefaction may be ascertained through an examination of the pressure gage and through the temperature indicated by the thermometer, 36.

In order that the operation may be continuous, two generators, AA', are employed. While the gas is being produced in one of these, the second is being prepared for action, so that the operation of the apparatus shall undergo no interruption.

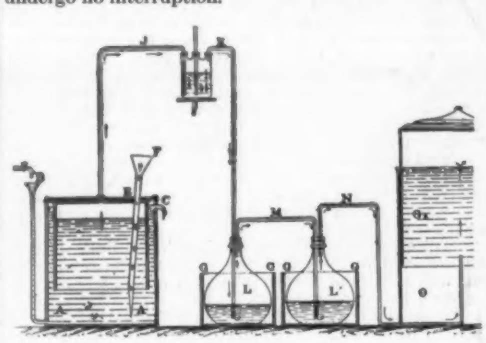


FIG. 26.—M. RAOUL PICTET APPARATUS.

The Raoul Pictet Process (Fig. 26).—In this process the carbide is thrown, piece by piece, through the tube, EF, into the reservoir, A, filled with water and cooled by a current of cold water, B, which afterward flows out through a waste pipe, C. The gas, in measure as it is formed, is collected in the holder, D. From the latter it passes into two series of cylinders, the first of which contain chloride of calcium and the second sulphuric acid at −21°. To this effect, these receivers, the object of which is to purify the gas, are placed in boxes, GG, filled with ice. The purified acetylene afterward flows to the gasometer, G z O, where it is stored up. This gas is afterward brought to a liquid state by means of the Pictet refrigeratory compressors. The liquefied acetylene is stored in nickel plated steel cylinders, which are tested for resisting a minimum pressure of 250 atmospheres. Fig. 27 represents one of these cylinders of a capacity of three gallons and Fig. 28 shows the upper part of one on a larger scale. The extremity of the cylinder, A, is closed by a screw plug, B, provided with a valve, and into which is screwed the device, D, for discharging the acetylene in the state

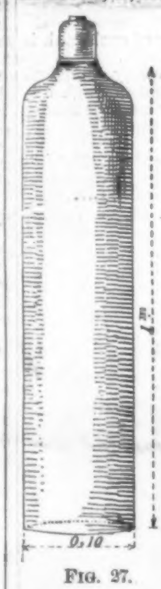


FIG. 27.

FIG. 28.

FIG. 27.—LIQUEFIED ACETYLENE CYLINDER.
FIG. 28.—STOPPER AND EXPANSION APPARATUS OF AN ACETYLENE CYLINDER.

of gas. To this effect, the wheel, F, that actuates the internal valve is opened, and the gas escaping from D passes into the expander, a, which is designed for giving a regular discharge. The pressure at the exit is indicated by the gage, b.

The cylinders of liquid acetylene are filled to only two-thirds of their capacity, and the pressure of the vapors of the liquid therein, according to the inventor, does not exceed from 40 to 50 atmospheres, at the warmest temperatures of summer.

The Canal Board of the State of New York, which is composed of the elective State officers, met on August 27 and adopted plans and specifications prepared by State Engineer Adams for work on the canal under the $9,000,000 canal improvement appropriation, to the amount of $3,126,301. The work is divided as follows: Eastern division Erie Canal, $626,499; middle division Erie Canal, $909,017; western division Erie Canal, $1,033,557; Champlain Canal, $409,502; Oswego Canal, $147,726. The board also approved estimates for canal improvement work under the general canal appropriation law passed by the last Legislature and special canal improvement appropriation, aggregating $207,000. This work will be advertised by Superintendent Aldridge at an early day.

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